IV — 9 — 40

THE

Mariners Magazine;

OR,

STURMY'S Mathematical and Practical ARTS.

CONTAINING,

The Deſcription and Uſe of the SCALE of SCALES; it being a Mathematical Ruler, that reſolves moſt Mathematical Concluſions: And likewiſe the Making and Uſe of the *Croſtaff*, *Quadrant*, and the *Quadrat*, *Nocturnals*, and other moſt Uſeful Inſtruments for all Artiſts and Navigators.

The ART of NAVIGATION, Reſolved Geometrically, Inſtrumentally, and by Calculation, and by that late Excellent Invention of *Logarithms*, in the Three Principal kinds of Sailing; with New Tables of the *Longitude* and *Latitude* of the moſt Eminent Places round the World, from the Meridian of the *Lizard*: And New Exact Tables of the Sun's Declination, newly Calculated; and of the *Longitude* and *Latitude*, *Declination* and *Right Aſcenſion* of ſome Eminent Fixed Stars.

TOGETHER WITH

A Diſcourſe of the Practick Part of NAVIGATION, in Working a Ship in all Weathers and Conditions at Sea.

A New Way of Surveying of Land, by the Mariners Azimuth or Amplitude Compaſs; very eaſie and delightful to all ſorts of Navigators, Mariners, or others.

The ART of GAUGING all Sorts of VESSELS; and the Meaſuring of Timber, Glaſs, Board, Stone, Walls, Cielings, and Tylings.

The ART of GUNNERY, Geometrically, Inſtrumentally, and by a moſt eaſie way of Calculation, by the Logarithm Tables, by Addition and Subſtraction, in the place of other Mens way of Arithmetick, of Multiplication and Diviſion: Alſo, Artificial Fire-Works for Sea and Land Service, as alſo for Recreation and Delight, with Figures.

ASTRONOMY, Geometrical, Inſtrumental, and by Calculation.

The ART of DIALLING by a Gnomonical Scale, and likewiſe by Calculation; Making all ſorts of Dials both without Doors and within, upon any Wall, Cieling, or Floor, be they never ſo Irregular, whereſoever the Direct or Reflect Beams of the Sun may come.

WHEREUNTO IS ANNEXED,

An Abridgment of the Penalties and Forfeitures, by Acts of Parliaments appointed, relating to the Cuſtoms and Navigation.

ALSO,

A COMPENDIUM of FORTIFICATION, both Geometrically and Inſtrumentally.

By Capt. SAMUEL STURMY.

LONDON, Printed by *E. Cotes* for *G. Hurlock*, *W. Fiſher*, *E. Thomas*, and *D. Page*; and are to be ſold at their Shops over againſt St. *Magnus* Church neer *London-bridge*, at the *Poſtern-gate* neer *Tower-hill*, at the *Adam* and *Eve* in *Little Britain*, and at the *Anchor* and *Mariner* in *Eaſt-Smithfield*. MDCLXIX.

1291:89

To the most August and Most Serene

MAJESTY
OF
CHARLES II.

King of *Great-Britain*, *France*, and *Ireland*,
Defender of the Faith, *&c.*

Most Gracious Sovereign,

YOur Majesties Royal Grandfather King *James*, the Peace-maker, was by the Wisest of His Age justly reputed worthy to be entituled *Great Britain's Solomon*, for His Wisdom, Learning, and Prosperous Government.

Your Pious and Judicious Father King *Charles* the First His esteem of the more Ingenuous and Politer Arts, *Sculpture*, *Picture*, and whatever else was Ancient or Excellent, drew hither into His own Galleries and Cabinets, and other Noble Palaces of this happy Island, the best Monuments of Old *Greece*, and of Modern *Rome*: And His own Incomparable Writings will demonstrate to succeeding Ages, how richly he was furnished with the best kinds of Knowledge, and with the truly Celestial and Divine Arts, which appeared in the whole

Courſe of His Life, but moſt of all in His laſt Sufferings.

And now Your Majeſty hath not only an Hereditary Claim to Your Anceſtors Virtues and Bleſſings, being by God's miraculous Providence and Protection reſtored, and redeemed from Your Fathers Calamities; but herein You have infinitely excelled them all, and that in the main, in that You are the firſt Founder of a Royal Inſtitution for the Advancement and Propagation of all Noble Arts and Beneficial Inventions: So that all the Kings in the Chriſtian World do emulate Your Great Example, and do value themſelves in nothing more, than that ſome of their wiſeſt Subjects do follow and adore the Foot-ſteps of Your *Royal Society*. And by this that Everlaſting Renown is already ſpread over the face of the whole Earth; it hath ſurrounded the Globe by Sea and Land; and we who are Borderers on the Shores, and all they who inhabite on the deep Seas, are witneſſes of the perpetual Ecchoes of your Fame, with this Averment, That the better Spirits in all the Univerſities of *Chriſtendom* are allured by Your Majeſties Luſtre to embrace and rejoyce in this Brighter Light, which can never henceforth be extinguiſhed. And this conſtrains as well all Your Loyal and True-hearted Subjects, as all Intelligent and Friendly Foreiners, to offer their Applauſes, Veneration, and Admiration.

But it is far above the reach of my Abilities

to

to make juſt report of theſe Great Deſigns, and of all Your Majeſties more than Heroical Accompliſhments. And yet I have a more Obliging and Perſonal Concernment: For as the Amplitude and Proſperouſneſs of Your Majeſties Dominions are chiefly maintained by Your Majeſties Countenance upon the Mathematical Arts, and eſpecially of *Navigation*; ſo Your Majeſty doth apparently excel all the Kings that ever were, in this Noble kind of Knowledge of the Naval Arts and Sciences. And for theſe, and many other good Reaſons, I hold it my bounden duty to lay theſe Eſſays of my beſt Endeavours at Your Royal Feet; and with the Proteſtation of a tryed and truſty Sea-man, to avouch, That not only my beſt Skill in Arts, but my Heart and Life alſo, are entirely devoted for Your Majeſties Service: And all my fellow Sea-men, and all true-hearted *Engliſhmen*, do joyn in this one Voice, *God ſave King* Charles *the Second.*

Moſt Gracious Sovereign,

Your Majeſties moſt Dutiful

and moſt Obedient Subject,

SAMUEL STURMY.

To the Honourable SOCIETY of

MERCHANT-ADVENTURERS

Of the CITY of

BRISTOL.

TO THE

MASTER, WARDENS, and ASSISTANTS

OF THE SAID

SOCIETY.

To my Honoured Friends

Sir *Robert Cann* and Sir *Robert Yeomans*, Knights and Baronets, Sir *Humfry Hooke*, Sir *Henry Creſwick*, Sir *John Knight*, and Sir *Thomas Langton*, Knights, *John Willoughby* and *John Knight*, Eſquires.

Honourable Gentlemen,

OUt of the great Reſpect I bear to you all of this Society, in regard from my Youth I have lived among you, and am a Burgeſs of your City, and have been commanded, and a Commander, and have ſailed to ſeveral Parts of the World out of this Port, I cannot commit theſe Productions of my Pen to the wide Ocean of fluctuating Opinions, without the aſſurance of the Protection of ſome Honourable Patronage, as your ſelves; without the which I might haply appear miſhapen, and monſtrous to the eye of the World, and uneaſily eſcape ſubmerſion; ſince that as the Year conſiſting of more foul than fair Days, ſo the World in truth affords more bitter Blaſts and virulent Cenſures of Detraction, than candid, ſerene, unprejudiced Judgment. Therefore I muſt repair to you, as to Seth's *Pillar, which in deſpight of whole Torrents of Oppoſers, and Cataracts of* Zoilus *his furious Off-*

ſpring,

ſpring, will (media inter prælia) ſecure theſe my poor Labours, and perpetuate them as indelible as the Stars, or your deſerved Honours, who of your Function are the Pillars of a Country, ſupporting all manner of Trade and Commerce in the World, and, like the induſtrious Bee, bringing Honey to every ones Hive, in adventuring your Eſtates to ſeveral Parts of the World, for the Good of many thouſands, which live and depend upon your Proſperity. I could, with many others, deſire, That this City and Society had in all reſpects the ſame Laws, and Cuſtoms in all Maritime Affairs, as the Honourable City of London: then would much Loſs, Charge, and Damage be prevented, that many times befals your Ships and Goods; a competent Company of Sea-men, for half Pay, would attend on board at the Ships going out, and coming home, until diſcharged; and that Pay would relieve themſelves, their Wives, and Children, and fit them for the Voyage, and be great ſatisfaction to them for their attendance on your Service: for by the Rules of Charity, The Labourer is worthy of his Hire; and none deſerve it more than Sea-men. Then would your Sea-mens Courage be fortified, Honeſty incouraged, and deſerving Men rewarded, and the Reformers of an ill Cuſtom be had in everlaſting memory, for the Good they did in their Generation. I humbly beg pardon for this Digreſſion, and humbly deſire that you would take it into conſideration. For my part I ever did, and ſhall to the utmoſt of my poor abilities endeauour to honour this City, and will adventure my Life to ſerve this Society in any Parts of the World.

Accept therefore this Off-ſpring of ſome ſpare Hours, improved more with an intent for the Publick Good, than for any Private Benefit.

I ſhall conclude this my Humble Addreſs with a Temporal and Spiritual wiſh, viz. That the Encreaſe of your Treaſures may anſwer your Hazards and Deſires, and that your Virtues and Graces may exceed your Treaſures in this Life; and in that to come, may your Glories as far tranſcend both, as Heaven doth Earth: And for this you have not only the earneſt Wiſhes, but the cordial Prayers of,

Your Honours moſt humble Servitor

to be Commanded,

SAMUEL STURMY.

Briſtol, 10 Novemb. 1667.

To my much Honoured Patron,

Sir *JOHN SHAW* Knight and Baronet:

And to the rest of the Honourable

FARMERS

OF

HIS MAJESTIES CUSTOMS,

Sir *John Wolstenholme*, Sir *Robert Vyner* Knights and Baronets; Sir *Edmond Turner* Knight, *Edward Backwell* and *Francis Millington* Esquires.

External, Internal, and Eternal Happiness be wished.

HONOURABLE SIRS,

MAN had at the first, and so have all Souls before their entrance into the Body, an Explicite Methodical Knowledge; but they are no sooner Vessel'd, but that Liberty is lost, and nothing remains but a vast confused Notion of the Creature. Thus had I only a Capacity without Power, and a Will to do that which was far enough above me. In this perplexity I studied several Arts, and put them into practice: For my own sullen Fate hath forc'd me to several Courses of Life; but I find not one hitherto which ends not in Surfeits or Society, and all

the Fortunes of this Life are Follies. Thus I rambled over all these Mathematical Inventions or Sciences, Wherefore (Honourable Sirs) *I having Composed, out of my poor Studies, this* Miscellany, *and considering there was nothing in it more useful for your Service than the Art of* Surveying, *knowing that you bestow Surveyors Offices upon many, but divers may be wanting in the Knowledge and Labour of the Art; my self once enjoyed both in your* Honours *Service, by the kind thankful Remembrance of my much Honoured* Patron: *but Envy soon eclipsed my Office without desert, and left me only my Art: Therefore* (*as St.* Paul *saith in another Case*) I will wait with Patience until my Change will come; *and in the mean time I am your Honours humble Servant, and humbly prostrate these my poor Labours at your Honours Feet, begging your Patronage thereof; knowing, That there was never any thing so well contrived by the Wit of Man, that hath not been subject to the Censure and Misconstruction of the Envious: Nor do I at this time* (*in the Production of this*) *expect Immunity from the Censorious Criticks of this present Age; yet for such was this Work never intended, but only for the Judicious, whose candid Censures I dare abide: But yet not without labour and difficulty can Books have passage into the World; therefore to the end the placid Fruits of these my Labours* (*now grown up among the wild Grapes of the Field*) *may be cherished and preserved from the turbulent Storms of discontented Spirits, it*

now

now being come to its Maturity and Perfection, muſt humbly implore the Protection of ſome Honourable Perſons to defend it: And being well aſſured (Sirs) *of your Honours moſt Heroick and Candid Diſpoſitions, I humbly caſt this into the Arms of your Humanity for Shelter and Protection; not doubting but that your refulgent Rays ſhining thereon, will be ſufficient to annihilate and diſpel the moſt dark and miſty Clouds aſcending our Horizon; which will not a little ſtrengthen both my preſent and future Undertakings for the Publick Good, and excite the Author to a grateful Acknowledgment of your Memorable Virtues, and to echo forth the Praiſes due to your Names and Eminencies. All that I have endeavoured, is to profit others, and to make my diligent and ſtudious Reader and Practicioner able to benefit his Country* (*which, certes, is no more than the Common Law of Humanity requires at all our Hands*) *and not, like ſome, to bury their Treaſures in the Aſhes of Oblivion; which puts me in mind of that excellent Saying of* Tullie, Non nobis ſolum nati ſumus. *Wherefore* (Honourable Sirs) *I have endeavoured, in as plain and ſuccinct a Method as I could imagine, to lay down the Art of* Surveying, *a new way, by the Mariners Sea-Compaſs, which is the beſt Inſtrument for their uſe and purpoſe, it agreeing ſo neer their Traverſe Rules at Sea, that there is very little difference. And likewiſe I have ſhewed the Sea-men the Land-man's Art of* Surveying *and* Gauging *all ſorts of Veſſels, and plain Superfi-*

cies and Solids; the Art of Gunnery, Artificial Fire-works, *and* Altronomy, *in the following Book; and so furnished the whole Work with such* Theorems *and* Problems, *Geometrically, Instrumentally, and by Calculation, as are most necessary and subservient thereunto: And therefore,* (Honourable Sirs) *you being able to protect it, I most humbly commit it to your gracious Protection, resting,*

Sirs,

St. Georges, or the Pill, near Bristol, Mar. 25. Anno 1669.

Your Honours most humble

and faithful Servant,

SAMUEL STURMY.

TO THE
Courteous Reader.

MAthematical Studies have for theſe many Years been much neglected, if not contemned; yet have there been ſo many rare Inventions found, even by Men of our own Nation, that nothing now ſeems almoſt poſſible to be added more. As in other Studies, ſo we may ſay in theſe, *Nil dictum quod non dictum prius*: We at the leaſt muſt needs acknowledge, That in this we have preſented thee with nothing new, nothing that is our own. *Ex integra graca, integram Comœdiam hodie ſum acturus*, ſaith *Terence*, that moſt excellent *Comedian*, in his *Heautontimorumenon*. *Tranſlation* was his Apology; *Tranſcription*, *Collection*, and *Compoſition*, ours. This only we have endeavoured, That the firſt Principles and Foundations of thoſe Studies (which were not to be known until now, but by being acquainted with many Books) might in a due method, and a perſpicuous manner, be as it were at once preſented to thy view.

Qui edefie en publick place, Faict maiſon trop haut ou trop baſſe.

Who builds i'th' way where all paſs by, Shall make his houſe too low or high.

The Matter, being Mathematical and Practical Arts of my own practice, I can the better avouch the eaſe and rruth of them to all ingenuous Practicioners, and unto ſuch as have as yet learned nothing but *Arithmetick*.

To that purpoſe, we have at firſt laid down ſuch Propoſitions, as all young Seamen are or ſhould be perfect in, concerning the Compaſs, and the Moon's Motion, Inſtrumentally and Arithmetically; and by it, in the ſame manner, how to know the Rules of the Ebbing and Flowing of the Sea, with the Rules of Time of Flood and High-water in any Port in the World; with a Diſcourſe of the Practick Part of *Navigation*, in working of a Ship in all Caſes and Conditions of Weather at Sea, to the beſt of my Experience.

And the A B C of *Geometry*, its Definitions and Geometrical Problems, out of *Euclid* and others, as muſt be known to ſuch as would know the Nature and Menſuration of *Triangles*. Next, We have proceeded to the Deſcriptions of all the moſt uſeful Inſtruments for Artiſts and Navigators; as the *Scale of Scales*, which is a Mathematical Ruler, that reſolves all Mathematical Rules whatſoever: And we our ſelves have fitted Tables and Diagrams in that manner, as we preſume has not been done in that plainneſs, and ſo eaſie to be underſtood, by any Man before. There is the *Diagrams* and *Tables* together, both Natural and Artificial; and the *Scale*, and its Making and Uſe follows. Secondly, The Making and Uſe of the *Traverſe-Scale* of *Artificial Points* and *Quarters*; The Making of the *Quadrant* and *Index*, and their ready Uſe in *Aſtronomy* and *Navigation*; and the *Protractor*; The Projection and Uſe of the *Nocturnal*, and new Tables of the *North Stars* Declination. And on the back-ſide are 32 of the moſt uſeful *Stars* in the Heaven for Navigators, and its Uſe;

with Tables of the *Longitude* and *Latitude*, *Right Aſcenſion* and *Declination*; The Deſcription and Uſe of the *Foreſtaff*, *Davis* his *Quadrant*; as alſo a new *Quadrant* and *Quadrat*, that I uſe my ſelf at Land and Sea; A Conſtant *Kalendar*, joyned with the Tables of the *Suns Declination*, for 32 years to come. And, Thirdly, The Nature and Quality of *Triangles*. And, Fourthly, Of Sailing by the *Plain Sea-Chart*, and the Uncertainty thereof; and of *Navigation* by *Mercator*, or Mr. *Wright*'s Projection, and by the neereſt way of Sailing by the *Globe*, or *Arch* of a *Great Circle*; with the making of the *True Sea-Chart*, Geometrically, Arithmetically, and Inſtrumentally, as the true way of keeping a Sea-Journal at Sea, very eaſie at once by *Plain*, *Mercator*, or *Great Circle* Sailing; with new Tables of *Longitude* and *Latitude* round the World, from the *Meridian* of the *Lizard*, terminating at 180 *deg*. *Eaſt* and *Weſt* of that *Meridian*.

The Fifth Book, The Art of *Surveying of Land* by the Sea *Azimuth* or *Amplitude Compaſs*, very eaſie and uſeful for Sea-men: The Art of *Gauging* of all ſorts of *Veſſels*, and Meaſuring of Timber, Stone, and Glaſs, and Ships, Geometrically, Inſtrumentally, and Arithmetically; and a moſt excellent *Gunners Scale*, with the eaſieſt way of *Gunnery* that hath been writ by any: For what *Nathaniel Nye* hath done by Arithmetick, by the *Square* and *Cube*, and their *Roots*, which is the hardeſt ſort of *Arithmetick*, by *Multiplication* and *Diviſion*, I have done by the *Logarithme Tables*, by *Addition* and *Subſtraction*, and likewiſe Geometrically and Inſtrumentally. The *Scale* ſhews at once, in a moment, the ready Dimenſions of twenty ſorts of moſt uſeful Ordnance, from a *Baſe* to a *Cannon-Royal*, their length, and weight of the Gun, Powder, and Shot, and Tables of weight of Shot of Lead, Iron, and Stone; with a Table of *Right Ranges* and *Point Blanks*; with a *Plain Scale* and *Dialling Scale*, *Quadrant*, and *Quadrat*, for taking of Heights and Diſtances; with a Line of *Inches* and *Numbers*, for the ready working all other Proportions of Solids, or otherwiſe; being a moſt uſeful Inſtrument for all Land and Sea *Gunners*: But moſt eſpecially I do adviſe all Sea *Gunners* to carry one of thoſe moſt uſeful Inſtruments in his Pocket, and by our Directions learn the Uſe perfectly of them. I am aſhamed to hear how ſenſleſly many Sea *Gunners* will talk of the Art, and know little or nothing therein, but only how to ſponge, lade, and fire a Gun at Random, without any Rules of finding the Diſpart, thickneſs of the Mettle in all places, and proportion any Charge of Powder thereto, and other Rules which ſhould be known. Herein how many of them are defective? And to ſupply that defect, I have taken this pains in the Art, to the end to help all ſuch as are ingenuous, and willing to learn: As alſo, all manner of Artificial Fire-works and Rockets, with their Figures and Fiery Arrows, Granadoes, and Pots.

The Sixth Book is the Art of *Aſtronomy*, containing the Definition of the Circle of the *Spheres*, with the manner how to reſolve all the moſt neceſſary Propoſitions thereto belonging, by a Line of *Chords* and *Sines*, and *Chords* and *Tangents*, and half *Tangents*, Geometrically and by Calculation, by the *Logarithme Tables* of *Artificial Sines* and *Tangents*: And all uſeful Aſtronomical Propoſitions appertaning to the *Firſt Motion*; and Tables for finding always the Suns true place; being all of extraordinary uſe, and made plain to the meaneſt Capacity.

Seventhly, The Seventh Book is the Art of *Dialling* by the *Gnomonical Scale*,

Scale, with the *Diagram* and making of the ſaid *Scales*, with Tables alſo in the Second Book deſcribed; with the *Fundamental Diagram* of all *Scales* on the *Ruler*, as alſo by Calculation, ſhewing the making of all ſorts of *Dials*, both within doors and without, upon any Wall, Ceiling, or Floor, be they never ſo irregular, whereſoever the direct or reflected Beams of the Sun may come, for any *Latitude*; and how to find the true Hour of the Night by the *Moon* and *Stars*; and how to Colour, Guild, and Paint *Dials*; and how to faſten the *Gnomon* in Stone or Wood. We have inſiſted the more upon it, and by our Explanation have endeavoured to make it plain and eaſie, it being all our own Practical Arts; ſo that nothing may be wanting, which either former Ages or our own (by Gods Bleſſing and their Induſtry) have afforded to us. We have to the *Artificial Canon* added out of Mr. *Wing*'s *Harmonicon Cœleſte*, *page* 263. the Rules to be taken and obſerved in uſe of Mr. *Gunter*'s *Canon* of *Artificial Sines* and *Tangents*, and Mr. *Brigs* his *Canon* of *Logarithme Numbers*, as in that Form, and in this Work, we have made uſe of his Directions in the Aſtronomical Calculation, and the Demonſtration by our own Rules; and of Mr. *Norwood*'s Advice in *Navigation*, and by Demonſtration our own (the way of our uſual practice at Sea in keeping our *Journal*) and for the *Longitude* and *Latitude* of Places, we have had the beſt Experience we could procure from the ableſt Pilots and Maſters that have been in the ſeveral Places of the World, and likewiſe of our own Obſervation of ſeveral Places in the *Weſt-Indies*, and other Parts of the World; together comparing of them with ſeveral *Tables*, formerly made and lately corrected, and fitted for a *Meridian* of our own Country, and the principal *Cape* of this Land, for thy eaſe; the *Lizard* being the farewel *Cape* to moſt Ships that ſail out of the *Britiſh* Seas, any way to the *South* or *Weſt*, and likewiſe the firſt Land made at their return home; and therefore it muſt needs be very uſeful for all Northern and Southern Navigators in their Voyages, with great eaſe and exactneſs.

It's nothing new, nor does it come by chance,
That Art is envy'd ſtill by Ignorance.

For the Art of *Gauging*, I have conferred with Mr. *Philip Staynred*, Mathematician and Gager in *Briſtol*; and all the Rules that have been laid down in the following Treatiſe, are moſt exact and eaſie to the meaneſt Capacity of ſuch as are skilful in *Arithmetick*; but with a great deal of Labour, Study, Care, and Charge, in the Tryal of the Practice of them by our ſelf: which may be conſidered by the Ingenuous Practicioners, though much more abuſed by ignorant *Momus* and his Mates, who make it their buſineſs to ſcoff, deride, affront, and abuſe all ſuch as are Ingenious, and pretend to have any thing more than themſelves; and you ſhall know them by their railing Diſcourſe of any Ingenious Work or Artiſt. For ſuch Loiterers there is a pair of Stocks fitted in Hell by the Devil, where for their malice, abuſes, curſed railings, and villainous revilings of thoſe that Study the Honour of their Country to Poſterity, the harmleſs ſtudy of Virtue, and praiſe-worthy commendation of all good honeſt-minded men; I ſay, ſuch *Momuſſes* will have their Heads in ſuch Stocks, and their Tails laſh'd by the Devils for ever, for their malice and envy, if

they give it not over, and repent of it in time. But for all honeſt-minded men that love Arts and Sciences, Theorical and Practical, God doth give them his Spirit to guide them in all Lawful Arts, to the knowledge thereof, according to their deſire of him.

Others that have either ſpent more time, or made a farther progreſs in theſe raviſhing Studies, might (if they would have taken the pains) have haply preſented thee with more in a leſs room; but the moſt of this was at the firſt collected for our private uſe, and direction of our three Brothers and Son; but now publiſhed for the good of others. Nevertheleſs, I am not ignorant, how that never any man living, in his writing, could pleaſe the phanſie of all men, neither do I expect to be the firſt. To pleaſe the envious, I cannot; for they are reſolute: To content the ſcornful, I will not attempt it: To flatter the haughty, were much folly: To diſſwade the capricious, were needleſs; and to perſwade the courteous, were unneceſſary. Let every one do as his *Genius* doth beſt diſpoſe him, take where he pleaſeth, read what he liketh, and leave what he liketh not. For my own part, I have with much diligence and induſtry waded through many ænigmatical Difficulties, and have removed and drawn back the Curtain of Darkneſs from off our *Engliſh Horizon*, in our *Mathematical and Practical Arts* following.

Laſtly, I deſire the Judicious Reader, if he chance to meet with any *Errata* (as ſome may happen in a Work of this Nature) that he would courteouſly amend them, and not with cavillation ungratefully requite my painful Labours. Haply, if this find acceptance, it may encourage me to publiſh ſome other thing, which perhaps may give thee much ſatisfaction, and be commodious to my Country-men of *England*. *Vale.*

Yours, and Urania's *Servant,*

St. Georges Pill,
10 Novemb.
1667.

SAMUEL STURMY.

To his Ingenious and Industrious Friend

Capt. SAMUEL STURMY.

A double Acrostick.

S –uch Noble Captains Honour well deserve,
A–s to their utmost, King and Country serve;
M–aking their Skill and Practice freely known
U–nto all others who will Learning own.
E–ast, West, North, South, thy Compass will them guide,
L–est they should wander with each Wind and Tide.

S –tir up thy Noble Genius, and go on;
T–hy Book shall live, when thou art dead and gon,
U–nto thy Glory: and proud Braggards will
R–epine they could not like thee shew their Skill.
M–omus may carp, but from all honest Hearts
Y–ou'l Thanks have for your MAGAZINE OF ARTS.

S–ome men, when they this MAGAZINE shall spy,
A–nd note the Author, presently will cry,
M–any such Captains will undo the Trade:
U–nlock these Secrets, all are Captains made.
E–vry thus, Devil-like, would keep men blind,
L–et Noble Sons of Art be free and kind.

S –o well stor'd, Captain, is thy MAGAZINE,
T–hat 'twill invite all sorts: This Bush of mine
U–nto thy Wine is needless. All men shall
R–eap Profit by thy Labours: and if all
M–en thus would add their Talents unto thine,
Y–ou'd soon compleat a famous MAGAZINE.

Non nobis solum nati sumus.

HENRY PHILLIPPES.

To

To His Worthy Friend the Author

Captain *SAMUEL STURMY.*

On his BOOK Entituled,

The MARINER's MAGAZINE.

Sweet gentle Reader, ſearch this Magazin,
And tell me then what thou haſt found therein:
Thou canſt not chuſe but ſay, There is ſuch ſtore
Of Mathematick Arts, *there needs no more.*
Well, to be brief, ſhould I extol thy Fame,
'Twould be in vain: Thy Book ſhall do the ſame.

PHILIP STAINRED.

To his Judicious Friend the Author

Capt. *SAMUEL STURMY,*

ON HIS

MAGAZINE of ARTS.

READER, *Survey, with an impartial Eye,*
The Care, *the* Pains, *the* Art, *the* Induſtry,
And Charge, *at which the* Author, *long, hath been,*
To Store (*with* Plenty) *this his* MAGAZEEN;
Or, rather, MART OF ARTS; *where you may buy*
(*For little Money*) INGENUITY:
And be Partaker of thoſe Arts *we call*
Sciences Liberal, MATHEMATICAL:
He having taken Pains *on th'* Deep *and* Shore,
Graſping *and* Grap'ling *to increaſe his Store;*
And after all his Toil *and* Pains (*thus ſpent*)
Gives *it his* Country *for an* Ornament.
Ranſack *this* CASCATE (*therefore*) *where you'l find*
Plenty *of* JEWELS *to adorn the* Mind.

Geometry. *And firſt, is repreſented to your Eye*
Selected Problems *in* GEOMETRY.

Navigation. *In* NAVIGATION *Rules it doth afford,*
Will make Men Sea-men *e're they go aboard:*
And when Embarked *on the* Ocean *far,*
May Steer *from th'* Artick *to th'* Antartick *Star;*

And

And ſo, with Prudence, *may a* Voyage *make*
Over the Ocean's Univerſal Lake:
No Places diſtance hindring of Commerce,
Having free Traffick *through the* Univerſe.

The GRODECIAN, *in this Book, may have* — Surveying.
Rules to Survey *his* Land, *and then his* Grave.

VINERIUS *now will find it no hard Task* — Gauging.
To know he hath his Due, and Gauge *his* Caſk.

Here MURIFRAGUS *certain Skill may gain* — Gunnery.
To reach his Mark, *making no* Shot *in vain.*

And fair URANIA *leads you by the Hand,* — Aſtronomy.
Deſcrying how the Spheres *to underſtand;*
Unlocking all the Hidden Treaſury,
And Secret Myſt'ries *in* ASTRONOMY.

In HOROMETRIA *Skill you may attain,* — Dialling.
To trace Sol's Courſe *out on a* Dial Plain.

And the MUNITOR *hither may reſort* — Fortification.
For Rules *whereby to* Fabricate *his* Forr,
To Spring *his* Myne, *and alſo* Sconces *raiſe*
Againſt his Foes, *to his Renown and Praiſe.*

And to the Trader *it will be a* Treaſure,
Yielding him Knowledge both in Weights *and* Meaſure.

With this, and ſuch like beneficial Skill,
Our Author This *his* MAGAZINE *did fill;*
And that for th' Good *and* Benefit *of thoſe*
Who honour Vertue, *and to* Vice *are Foes.*
Conſider, then, th' elaborate Pains *he took,*
And thank him as thou profit'ſt by his BOOK.

WILL. LEYBOURN.

In Praiſe of his Dear Friend the Author, for his ART,

Capt. *SAMUEL STURMY.*

OUr Artiſt here, I am ſo bold to tell ye,
Treats of no Toys, nor does he Baubles ſell ye;
Though ſuch like ſtuff indeed, it well may be,
Y' have met i' th' Mathematicks Theory:
Where he is for the Practick, *and does ſlight*
All ſuch as but Theorically write.
'Tis much and high, you'l ſay; but 'tis as ſure,
Such Practick Works *for ever will endure.*
And as your fluent Naſo *dropp'd before,*
Theſe will be read where e're our Cannons rore.
Here is no trivial Traſh, or frothy Rhimes,
To Drunkards grateful at their tippling times.
Here's no Acroſticks, *nor no* Anagrams,
In Combs and Sciſſors for th' Barbarians:
Much leſs your Epigrams, *and ſuch like Toys,*
For Children fit, or at the beſt for Boys:
No novel Romance, *nor no paultry* Plays,
To wear out Time with, and miſ-ſpend our Days.
The Matter here is all ſublime and high,
That bears his Name unto the Starry Sky.
But if you neerly mark him, and his End,
You muſt confeſs, he doth them all tranſcend.

WILLIAM BERWICK, jun.

The

The Author to His Book.

Go forth, thou ſhapeleſs Embryon *of my Brain,*
Unfaſhion'd as thou art; expreſs the ſtrain
And Language of thy diſcontented Sire,
Who hardly ranſom'd his poor Babe from fire,
To offer to the World, and careleſs Men,
The timeleſs Fruits of his officious Pen.
Thou art no lovely Darling, ſtamp'd to pleaſe
The Looks of Greatneſs; no Delight to eaſe
Their melancholy Temper, who reject,
As idle Toys, but what themſelves affect.
No lucky Planet darted forth his Rays,
To promiſe love unto thy Infant Days.
Thou maiſt, perhaps, be Merchandiſe for Slaves,
Who ſell their Authors wits, and buy their Graves.
Thou maiſt be cenſur'd guilty of that blame,
Which is the Midwifes fault, the Parents ſhame:
Thou maiſt be Talk for Tables, us'd for ſport
At Tavern-meetings, Paſtime for the Court.
Thou maiſt be torn by their malicious Phangs
Who ne're were taught to know a Parents Pangs.
How eas'ly can proud Ignorance out-ſtare
The comlieſt Weeds thy Poverty can wear?
When all the Siſters on our Iſle
Are oft ſworn Servants to aſpiring Pride;
And our renowned Mother Athens groans,
To ſee her Garden ſet with Cadmus *Sons,*
Whoſe Birth is mutual Striſe, whoſe Deſtiny
Is only to be born, to fight, and die.
Prometheus *is chain'd faſt, and cannot move*
To ſteal a little Fire from mighty Jove,
To People new the World, that we may ſee
Our Mother teem with a new Progeny.
And therefore with thy hapleſs Father prove
To place thy Duty, where thou findeſt Love.
When thou arriv'ſt at Court, thou long mayſt ſtay
Some Friends aſſiſtance, to prepare thee way;
As in a cloudy morning I have done,
When envious Vapours ſhut me from the Sun.
When all elſe enter, ſee thou humbly ſtand,
To beg a Kiſs from thy Mæcenas *Hand:*
If He vouchſafe a Look to guild thy State,
Proclaime Him Noble, *thy ſelf Fortunate.*

S. S.

THE AUTHOR'S COMPLAINT.

HOw in these days are Artists now regarded!
No, not so much as Oil or Ink rewarded.
Yet shall a Sycophant, or Rhiming Knave,
If he but Impudence and gay Clothes have,
Can harp upon some scurr'lous Jest or Tale,
(Though fifteen times told, and i' th' City stale)
Command a Great Mans Ear, perhaps be able
To prefer Suits, and elbow at his Table,
wear speaking Pockets, boast whom he doth serve;
When meriting Men may either beg or starve.
Mean time we spend our fruitless Hours in vain,
And Age of want and hunger doth complain.
It grieves us now, although too late at last,
Our time in painful Studies to have past;
And what a Folly 'tis we now have found,
To cast our Seed in an unfruitful Ground;
That in time past we have laid up no store,
Which might maintain us when our Heads be hoar;
And that our shaken Vessels, torn and thin,
Can find no easie Port to harbour in.
Then, barren Arts, seek out some other Friend;
For I henceforth a thriving Course intend.
None will with Violets my Ashes grace,
Or strew sweet fragrant Roses in the place.
If any loves me, and intends to give,
I wish to taste his Bounty whilst I live.
What do I care, when Fates my Thred have spun,
Though Briars and Thorns my Grave shall over-run.

Impiger extremos currit Mercator ad Indos,
Per mare pauperiem fugiens, per saxa, per ignes.

AN

AN INDEX, SHEWING, The CONTENTS of the SEVEN BOOKS OF THE MARINER'S MAGAZINE.

BOOK I.

THe Deſcription of Navigation in general. Page 1

Of what is needful firſt to be known in the Practick Part: And of the Compaſs; and how to divide the Circles and Parts. 3

The Moon's Motion, and the Ebbing and Flowing of the Sea. 6

The making a moſt uſeful Inſtrument for the Moon. ibid.

The Variation-Compaſs, and the Uſe thereof, in 10 *Propoſitions.* ibid.

The finding the Golden Number, or Prime, and Epact, according to the Engliſh *Accompt, and all other things relating to the Moon and Tides, Arithmetically.* 9

The Practick Part of Navigation, in Working a Ship in all Weathers and Conditions at Sea. 15, to 22

Geometrical Definitions. 22

Geometrical Problems. 28, to 43

BOOK II.

THe Argument, and Deſcription of Inſtruments in general. Page 45

A Deſcription of the Fundamental Diagram, and Tables for the making of the Lines of Chords and Rumbs, as alſo of Sines, Tangents, and Secants Natural, on the Scale; and of what Inſtruments you muſt be provided with before you can make Inſtruments for Mathematical Uſes. 47

The Explanation of the other half of the former Semicircle, being a Deſcription of the Fundamental Diagram of the Dialling Scale on the Mathematical Ruler; with a Table for the dividing of the Hours and Minutes on the ſame; a Table for the dividing of the Gnomon-line on the Scale, called by ſome a Line of Latitudes, *as alſo a Table of Tangents for five Hours, to every five Minutes of an Hour, for the inlarging the Hour-line Scale.* 55

The Scales or Lines on the back-ſide of the Mathematical Ruler, viz. *A Line of Artificial Numbers, with a Table how to make the ſame; A Table of Artificial Tangents, and how to make the Line; as alſo a Table of Artifi-*

cial Sines; The making of Mercator's *Meridian Line, by our Table of Meridional Parts, in Leagues and* 10 *parts of a League: And the Æquinoctial is the Line of Equal parts, by which the Table of Numbers were taken out, and the Lines made by.* Page 58

How to calculate and make a Table for the Diviſion of the Scale of Reduction, and the uſe thereof. 62

A Table for the diviſion and making of the Artificial Rumbs, or Points, Halfs, and Quarters, on the Traverſe Scale. 63

How to make a Quadrant, which will reſolve many Queſtions in Aſtronomy by the help of an Index, and alſo very uſeful in Navigation; with the Uſe thereof in Aſtronomy and Navigation, in ſeven Sections. 64

To find how many Leagues do anſwer to every Rumb and Quarter, in ſix Propoſitions in Navigation. 70

How to make a uſeful Protractor. 71

The Projection of the Nocturnal, and the Uſe thereof by the North Star. 73

How to uſe the Pole Stars Declination, and thereby to get the Latitude, with the Table. 74

How to make a moſt uſeful Inſtrument of the Stars on the back ſide of the Nocturnal, and by it to know moſt readily when any of 31 *of the moſt notable Stars will come to the Meridian, what Hour of the Night at any time of the Year, at the firſt ſight; with a Table of the Longitude and Latitude from the beginning of the Year* 1671; *with the Right Aſcenſion and Declination of* 31 *of the moſt notable fixed Stars, Calculated from* Tycho *his Tables, Rectified from the Year of our Lord* 1671. 76

The Uſe of the moſt uſeful Inſtrument of the Stars, how to know the Hour of the Night any Star comes to the Meridian in any Latitude; and how to know what Stars are in Courſe at any Time or Day of the Year. 77

The Deſcription and Uſe of 3 *Stars called the* Croſiers. 78

A Deſcription of the making of the Croſs-ſtaff, and how to uſe the ſame fully. 79, to 85

A Deſcription and Uſe of the Quadrant or Back-ſtaff, in ſix Propoſitions, declaring the Uſe thereof in all Obſervations. 85

The Deſcription and Uſe of the moſt uſeful Quadrant for the taking of Altitudes of the Sun or Stars, on Land or Sea, backwards or forwards, or any other Altitude of Hills, Trees, Caſtles, or Things whatſoever. 92

A Conſtant Kalendar or Almanack for 300 *Years; but more exactly ſerving for* 19 *Years, being the Circle of the Moon, or the Golden Number; with new exact Tables of the Suns Declination, rectified by the beſt Hypotheſis until the Leap-years, and the Uſe thereof.* 101, to 122

BOOK III.

CHAP. I. *Of the Nature and Quality of Triangles.* Page 123

CHAP. II. *Containing the Doctrine of the Dimenſions of Right-lined Triangles, whether Right-angled or Oblique-angled; and the ſeveral Caſes therein reſolved, both by Tables, and alſo by the Lines of Artificial Numbers, Sines, and Tangents.* 125

CASE I. *In a Right-angled Plain Triangle, the Baſe and the Angle at the Baſe being given, to find the Perpendicular,* 126

CASE II.

CASE II. *The Baſe and the Angle at the Baſe being given, to find the Hypothenuſal.* Page 127
CASE III. *The Hypothenuſal and Angle at the Baſe being given, to find the Perpendicular.* 128
CASE IV. *The Hypothenuſal and Angle at the Baſe being given, to find the Baſe.* 129
CASE V. *Let the Perpendicular be the Difference of Latitude 253 Leagues, and the Angle at C be* S W b W 1 deg. 45 min. Weſterly, *or* 58 deg. *let it be given to find the Hypothenuſal.* 129
CASE VI. *The Hypothenuſal or Diſtance ſailed, the Perpendicular of Difference of Latitude given, to find the Rumb.* 130
CASE VII. *The Hypothenuſal, and the Parallel of Longitude, and the Radius given, to find the Rumb or Courſe ſailed.* ibid.
CASE VIII. *Having two Angles and a Side oppoſite to one of them given, to find the Side oppoſite to the other.* 131
CASE IX. *Two Sides and an Angle oppoſite to one of them being given, to find the Angle oppoſite unto the other.* 132
CASE X. *Having two Sides and the Angle contained by them given, to find either of the other Angles.* ibid.
CASE XI. *Two Sides and their contained Angle given, to find the third Side,* 134
CASE XII. *Three Sides of an Oblique Triangle being given, to find the Angles.* ibid.

BOOK IV.

CHAP I. OF *Sailing by the Plain Chart, and the Uncertainties thereof; and of Navigation, with its parts.* Page 137
Queſtions of Sailing by the ordinary Sea-Chart. 140
CHAP. II. *Declaring what muſt be obſerved by all that keep Accompt of a Ships Way; and to find the true Point of the Ship at any time, according to the Plain Chart.* 144
Directions how we do keep our Reckonings at Sea by the Log-board, and alſo by our Journal Book. 145
CHAP. III. *A formal and exact way of ſetting down and perfecting a Sea-Reckoning.* 147
A Traverſe-Table for every Point, Half-Point, and Quarter-Point of the Compaſs, to the hundredth part of a League or Mile, which gives the Difference of Latitude and Departure from the Meridian. 149
Examples and Uſe of the Tables, with a Journal from Lundy *to* Barbadoes *by the Plain Chart.* 153
The Plain Sea-Chart, and how to make it, and the Uſe thereof. 156
CHAP. IV. *How to correct the Accompt when the Dead Latitude differs from the Latitude by Obſervation.* 157
CHAP. V. *How to allow for known Currents, in eſtimating the Ships Courſe and Diſtance.* 159, 160
CHAP. VI. *Curious Queſtions in Navigation, and how to reſolve them Geometrically and by Calculation.* 161
CHAP. VII. *The diſagreement betwixt the ordinary Sea-Chart and the Globe;*

Globe; and the agreement betwixt the Globe and the True Sea-Chart, made after Mercator's *way, or Mr.* Edward Wright's *Projection; with the use thereof.* Page 166

A Table of Meridional Parts to the tenth part of a League, and for every 10 *Minutes of Latitude, from the Æquinoctial to the Poles, with the use thereof in* Mercator's *Sailing, Geometrically and by Calculation.* 169

CHAP. VIII. *How to divide a Particular Sea-Chart according to* Mercator *and Mr.* Wright's *Projection.* 174

CHAP. IX. *The Projection of the Meridian-line by Geometry; and how to make a Scale of Leagues for to measure Distances in any Latitude.* 184,185

CHAP. X. *The way of Sailing by a Great Circle.* 176

CHAP. XI. *How to find the true distance of Places, one of them having no Latitude, the other having Latitude and Difference of Longitude less than* 180 deg. *To find* (1) *Their Distance in a Great Circle,* (2) *The direct Position of the first Place from the second,* (3) *And the second Place from the first.* 179

CHAP. XII. *The Description of the Globe* in Plano, *and the several Conclusions wrought thereby.* 189

CHAP. XIII. *To Calculate the Arch of a Great Circle for every fifth or tenth Degree of Latitude or Longitude.* 192

CHAP. XIV. *How by the Scale of Tangents to make a part of the Globe in* Plano, *whereby you may trace out the Latitudes to every Degree of Longitude, or every* 5 *or* 10 *Degrees, as neer as you will desire, without Calculation.* 193

CHAP. XV. *By the Latitude, and Difference of Longitude from the Obliquity, to find the true Great Circles Distance.* 196

CHAP. XVI. *How to make the Truest Sea-Chart, and the Use thereof in* Mercator's *and Great Circle Sailing, called a General Chart.* 200

CHAP. XVII. *How to keep a true and perfect Sea-Journal by Plain Sailing and the True Sea-Chart, together with the Explanation thereof.* 202

CHAP. XVIII. *A Description of the Table of the Latitude and Longitude of Places, and the way how to find both.* 206

BOOK V.

CHAP. I. *THe Art of Surveying Land by the Azimuth or Amplitude Compass, with the Description thereof; as also the Staff and Chain, with the Use thereof.* Page 1

How to measure a Square piece of Ground. 4

To measure a Long Square piece of Ground by the Line of Numbers and Arithmetick. 5

How to measure a Triangular piece of Ground. 6

How to measure a piece of Ground of four unequal Sides, called a Trapezia. ibid.

How to measure a piece of Ground being a perfect Circle. 7

How to measure an Oval piece of Ground. 8

How to measure a piece of Ground lying in form of a Sector. ibid.

To measure a piece of Ground being a Segment or part of a Circle. 9

Having the Content of a piece of Ground in Acres, to find how many Perch of that Scale was contained in one Inch whereby it was Plotted. ibid.

CHAP. II.

CHAP. II. *How to take the Plot of a Field at one ſtation, taken in the middle thereof, by the Compaſs.* Page 11
CHAP. III. *How to take the Plot of a Field at one ſtation, taken at any Angle thereof.* 13
CHAP. IV. *How to meaſure an Irregular piece of Ground, by reducing the Sides into Triangles and Trapezia's, and how to lay it down in your Field-Book.* 14
CHAP. V. *How to take the Height of* Tenariffe, *or any other Iſland or Mountain.* 18
CHAP. VI. *How to find the diſtance of a Fort or Caſtle, or the breadth of a River, by two ſtations, with the Quantity of the Angle at each ſtation.* 21
CHAP. VII. *How to take the diſtance of divers Places one from another, and to protract as it were a Map thereof by the Compaſs and Plain Scale.* 24
CHAP. VIII. *The Art of Gauging of Veſſels by the Line of Numbers, and the Lines on the Gauging Rod or Staff, and by Arithmetick.* 26
The true Content of a ſolid Meaſure being known, to find the Gauge-point of the ſame Meaſure. ibid.
The Deſcription of the Gauging Rod or Staff. 27
The Deſcription of Symbols of Words for brevity in Arithmetick. ibid.
How to meaſure a Cubical Veſſel. 28
How to meaſure any ſquare Veſſel. ibid.
How to meaſure a Cylinder Veſſel. 29
How to meaſure a Veſſel in form of a Globe. ibid.
How to meaſure a Barrel, Pipe, Butt, Puncheon, Hogſhead, or ſmall Cask, ibid.
How to find the Quantity of Liquor in a Cask that is part full. 31
How to meaſure a Brewers Tun or Maſh-vat. 32
How to meaſure a Cone Veſſel. 33
How to meaſure a Segment of a Globe or Sphere. 34
How to reduce Ale-meaſure into Wine, and likewiſe to reduce Wine-gallons into Ale. ibid.
How to meaſure a Brewers Oval Tun. ibid.
CHAP. IX. *Wherein is ſhewed, How to meaſure exactly all kinds of Plain Superficies, both by Arithmetick and Inſtrumentally.* 36
How to meaſure a Wall of an Houſe in form of a long Square. ibid.
How to meaſure Boards, Glaſs, Pavement, Wainſcot, and the like. 38
How to meaſure ſolid Bodies, as Timber and Stone. ibid.
To find how many Inches in length will make one Foot of Timber, being alike in the Squares. 39
How to meaſure a Cylinder or a Tree whoſe Diameters at the ends be equal. 40
How to meaſure a round piece of taper Timber. 41
How to meaſure a Pyramidal piece of Timber. ibid.
How to meaſure a Conical piece of Timber. 42
How to find the Burden of a Ship. 43
The Uſe of the Line of Numbers in Reduction and the Rule of Three. 44
CHAP. X. Sect. 1. *The Art of Gunnery, by a New-invented, Uſeful, and Portable Scale.* 45
Sect. 2. *The Qualifications each Gunner ought to have, and his Duty and Office.* ibid.
Sect. 3. *The Deſcription and Uſe of the Gunners Scale on both Sides.* 47

Sect. 4. *The Uſe of the Line of Numbers on the edge of the Scale, for the help of ſuch as cannot extract the Square and Cube Roots.* Page 49
Sect. 5. *As likewiſe how by the Logarithm Tables and Addition and Subſtraction, to Reſolve with wonderful eaſe all Concluſions in the Art of Gunnery.* 50
Sect. 6. *The Geometrical finding the Diameter for the weight of any Shot aſſigned.* 51
Sect. 7. *How to find what Proportion is between Bullets of Iron, Lead, and Stone; by knowing the weight of one Shot of Iron, to find the weight of another Shot of Lead, Braſs, or Stone, of the like Diameter.* 53
Sect. 8. *How by knowing the weight of one Piece or Ordnance, to find the weight of another Piece of the ſame ſhape, and the ſame Metal, or any other Metal.* 54
Sect. 9. *How to make a Shot of Lead and Stone in the ſame Mold, of the ſame Diameter as the Iron Shot is of.* 55
Sect. 10. *How by knowing what Quantity of Powder will load one Piece of Ordnance, to know how much will load any other Piece whatſoever.* 56
How to make the true Diſpart of any true beared Piece of Ordnance, or otherwiſe, to know whether the Piece be Chamber-beared. 57
To know what Diameters every Shot muſt be of to fit any Piece of Ordnance. 58
To find what Flaws, Cracks, or Honey-combs are in any Piece of Ordnance; and likewiſe to find whether a Piece of Ordnance be true beared, or no. ibid.
Of Iron Ordnance, what Quantity of Powder to allow for their Loading; and what Powder to allow for Ordnance not true beared. 61
How Molds, Forms, and Cartrages are to be made for any ſort of Ordnance. 63
How to make Ladles, Rammers, Sponges, for all ſorts of Ordnance; and how the Carriage of a Piece ſhould be made. ibid.
How much Rope will make Britching and Tackle for any Piece. 64
What Powder is allowed for Proof, and what for Action. ibid.
The difference between common Legitimate Pieces, and Baſtard Pieces. ibid.
How Powder is made, and the ſeveral ways to know when it is decaying. 65
How to make excellent good Match; and how to make Powder that it ſhall not waſte with Time, and how to make good that which is bad, and how to make Powder of divers Colours. 66
Several ſorts of Saltpetre, and how to make an excellent ſort, very eaſie, and leſs Charge; and how to load and fire a Piece of Ordnance like an Artiſt. 67
The difference of ſhooting by the Metal, and by a Diſpart, by Right Ranges, and at Random; with the Figures thereof, 68
How to make a good Shot to any place aſſigned, out of any Gun. 70
How to make an effectual Shot out of a Piece of Ordnance at Random. 72
How to find the Right Line or Range of any Shot diſcharged out of any Piece, for every Elevation, by one Right or Dead Range given for the Piece aſſigned: And to know how much of the Horizontal Line is contained under the Right Line of any Shot made out of any Piece, at any Elevation. 74
Of the violent, crooked, and natural Motion or Courſe of a Shot, diſcharged out of any Piece of Ordnance aſſigned. 75
How to make a Gunners Ruler, and how to divide the ſame, by the help of a Table, fitting it for any Piece; and how to give Level with the Gunners Ruler at any Degree of Random. 76
How to give Level to a Piece or Ordnance without the Gunners Rule. 78
How to make a Shot at the Enemies Light in the Night. 79

How to ſhoot perfectly at a Company of Foot or Horſe, or a Ship under ſail. P. 79
How the ſame Powder in weight ſhall carry the Shot more cloſe or ſcattering: And how a Shot that ſticketh faſt within the Concavity of the Piece, that cannot be driven home, may be ſhot out without any harm to the Gunner; and what difference there is in ſhooting out of one Piece ſeveral Shots together. ibid.
Sect. 46. *How to weigh Ships that are ſunk, or Ordnance under Water; or to know what empty Cask will carry any ſort of Ordnance over a River.* 80
How many Oxen, Horſes, or Men, will ſerve to draw a Piece of Ordnance. 81
How Gunners may take a Plot of their Garriſon, and every Object therein, or neer it. ibid.

Artificial Fire-works.

A Deſcription of the Mortar-piece: How to make one of Wood and Paſte-board: How to fit and prepare Granadoes for the Mortar-piece: How to make Fuces. 83
How to make Granadoes of Canvas for the Mortar-piece; and how Granadoes are to be charged in a Mortar-piece, and fired. 84
How to make Hand-granadoes, to heave by Hand. 85
How to make Fiery Arrows or Darts, like Death-Arrows Heads. ibid.
How to make Fiery Pots of Clay, and Powder Cheſts. 86
How to make Artificial Fire-works for Recreation and Delight. ibid.
How to make Compoſition for Rockets of any ſize, and how to fire them. 87
How to make Fiery Serpents and Rockets that will run upon a Line, and return again; and how to make Fire-wheels, as ſome call them, Girondels. 88
How to make divers Compoſitions for Stars, and the Uſe of them. 89
How to repreſent divers ſorts of Figures in the Air with Rockets. ibid.
How to make Silver and Golden Rain, Fire-Lances, and Balloons for the Mortar-piece; and the Figures of the moſt uſeful ſorts of Fire-works, and the Explanation thereof. 90
Moſt Precious Salves for Burning by Fire. 91

Book VI.

The Projection of the Sphere by Tangents and half Tangents. 94
The Rudiments of Aſtronomy put into plain Rimes. 95
The Definitions of the Circles of the Sphere, and Imaginary Circles, which are not deſcribed in a Material Sphere or Globe. 97
The Projection of the Sphere in Plano, *repreſented by the* Analemma; *and the Points and Circles before deſcribed in a Convex and a Concave Sphere, by Chords and Sines, and likewiſe reſolved by Chords and Tangents.* 101
How to Calculate the Suns true Place, and the Table of his mean Motion. 105
Probl. 2. *The Suns diſtance from the next Æquinoctial Point, and his greateſt Declination being given, to find the Declination of any Point required.* 107
Probl. 3. *Having the Suns greateſt Declination, and his diſtance from the next Æquinoctial Point, to find his Right Aſcenſion.* 108
Probl. 4. *The Elevation of the Pole and Declination of the Sun being given, to find the Aſcenſional Difference.* 109

Probl. 5. *The Suns Right Aſcenſion, and his Aſcenſional Difference being given, to find his Oblique Aſcenſion and Deſcenſion.* Page 110
Probl. 6. *To find the time of Sun-riſing and ſetting, with the length of the Day and Night.* ibid.
Probl. 7. *The Elevation of the Pole and the Declination of the Sun being given, to find his Amplitude, and by it to know the Variation.* 111
Probl. 8. *Having the Latitude of the Place and the Suns Declination, to find when the Sun comes to the due Eaſt and Weſt.* 112
Probl. 9. *The Elevation of the Pole and the Declination of the Sun being given, to find the Suns Altitude when he comes due Eaſt and Weſt.* ibid.
Probl. 10. *The ſame being given, to find his Altitude at the hour of ſix.* 113
Probl. 11. *The ſame being given, to find his Azimuth at the hour of ſix.* ib.
Probl. 12. *Having the Latitude of the Place, and the Suns Declination and his diſtance from the Meridian being given, to find the Suns Altitude at any time aſſigned.* 114
Probl. 13. *The Latitude of the Place, and the Suns Altitude and Declination being given, to find the Suns Azimuth, and by it how to find the Variation.* 118
Probl. 15. *How to find the Altitude of the Sun by the Shadow of a Gnomon ſet perpendicular to the Horizon, by Scale and Compaſs, as alſo by Calculation.* 122
Probl. 16. *Having the Latitude of the Place, the Declination of the Sun, and the Suns Altitude, to find the hour of the day,* 123
Probl. 17. *Having the Azimuth of the Sun, and his Altitude, to find the hour of the day.* 124
Probl. 18. *How to find the Right Aſcenſion of a Star, and the Declination of a Star, having the Longitude and Latitude of the Star given.* ibid.
Probl. 19. *Having the Declination and Right Aſcenſion of a Star, to find the Longitude and Latitude thereof.* 126
Probl. 20. *Having the Meridian Altitude of an unknown Star, and the diſtance thereof from a known Star, to find the Longitude and Latitude of the unknown Star.* 128
Probl. 21. *To find the Parallax of Altitude of the Sun, Moon, and Stars.* 131

BOOK VII.

THe Fundamental Diagram of the Dialling Scale, and the Argument. P. 1
The Preface of the kinds of Dials, and Theorems premiſed. 2
How to make the Polar or Æquinoctial Dial, and how to place it. 5
How to make the Æquinoctial Dial, or Polar Plane, Geometrically, and by Calculation. 8
How to make the Eaſt Æquinoctial Dial, or the Weſt, Lat. 51 d. 30 m. 9
How to make a Vertical Horizontal Dial. 11
How to make a South inclining 23 deg. *in Latitude* 51 d. 30 m. 14
How to obſerve the Declination of any Declining Plane. 15
How to take the Declination of any Wall or Plane, without the help of a Needle or Lead-ſtone. 16
How to make a Declining Horizontal Dial, or South erect declining from the South Eaſtward. 17

The Contents.

To find how much time the Subſtiler is diſtant from the Meridian, or Inclination of Meridians, Geometrically and by Calculation. 18

How to draw the Hour lines in a Declining Horizontal Plane, or South Erect declining 32 d. 30 m. *from the South Eaſtward.* 19

How to obſerve the Reclination or Inclination of any Plane. 21

How to draw Hour-lines in all Declining Reclining Inclining Planes. ibid.

How to deſcribe the Sphere or Diagram. 22

How to make a North or South Reclining Dial 23

How to make an Eaſt and Weſt Reclining or Inclining Dial. 25

How to find the Arches and Angles that are requiſite for the making of the Reclining Declining Dials. 27

How to draw the Reclining Declining Dial. 30

How to find the Horary diſtance of a Reclining Declining Dial. 31

How to know in what Country any Declining Dial ſhall ſerve for a Vertical. 33

How to find the Arches and Angles which are requiſite in a North Decliner Recliner, and a South Decliner Incliner. ibid.

How to draw the Declining Inclining Dial. 36

How to know the ſundry ſorts of Dials in the Fundamental Diagram of the Sphere. 37

How other Circles upon the Sphere may be deſcribed upon Dials, beſides the Meridians. 38

How to deſcribe on any Dial the proper Azimuths and Almicantars of the Plane. 39

How to deal with Declining, Reclining, or Inclining Planes, where the Pole is but of ſmall Elevation. ibid.

How to inlarge the Hours of any Plane. 40

How to make a Vertical Dial upon the Cieling of a Floor within doors, where the direct Beams of the Sun never come. 42

A Table for the Altitude of the Sun in the beginning of each Sign, for all the Hours of the Day, for the Latitude of 51 d. 30 m. 44

How to make an Univerſal Dial on a Globe, and how to cover it if need requires. 45

How to make a North Dial for the Cape of Good Hope, *in South Latitude* 35 deg. *and Longitude* 32 deg. 54 min. *to the Eaſtward of the Meridian of the* Lizard. 46

How to find the Hour of the Night by the Moon ſhining upon a Sun-dial. 48

How to find the Hour of the Day or Night by a Gold Ring and a Silver Bowl, or Braſs, Glaſs, or Iron Veſſel. ibid.

How to Paint the Dials that you make, and faſten the Gnomons in Wood or Stone. 49

The Uſe of the Tables of Artificial Sines and Tangents. 50

The Uſe of the Logarithme Numbers. 51

Next follow the Tables.

After them is an Abridgment of Cuſtom-Laws in Navigation.

And laſt of all is annexed, A Compendium of Fortification both Geometrically and Inſtrumentally.

TO THE

Truly Industrious, and Highly Deserving of *English-men*

Captain *SAMUEL STURMY.*

On his Excellent and Elaborate Treatise, Entituled,

THE MARINERS MAGAZINE, *&c.*

IF Earth *and* Water *make one* Globe, *then he*
Must like a Stranger *to his* Country be,
That's ignorant in Navigation;
And is indeed the out-side *of a* Man.
For he that's truly Microcosmical,
Owns Noah's Ships, *as well as* Adam's Fall.
The Sun *and* Man *(they say)* beget *a* Man:
A Mensal-Line *appends to* David's Span:
Who thinks by Retail-pow'r *his* Kind *to keep,*
And merrily expose the Sun *to* Sleep,
May of a Kingdom *soon a* Cottage *make,*
And Fences *build to't, without* Wall *or* Stake.
Nature *requires no* Miracles, *but proceeds*
In Order, by Fit Causes, *as she needs.*
And he's the true Philosopher, *who* views
Earth, Sea, *and* Sky; *not he on* Earth *doth* Muse.
Can any *by* one Season *understand*
That this our Earth, Four *diff'rent ones command?*
Or that Physician *reach* Anatomy,
Who knows nor Bladder *or* Emunctory?
Or can the Ablest Theorist *deny*
That Just Experience's *witness'd by the* Eye?
Who to such Sophistry *their* Reason *bow,*
Lift Fallax *up, and set the* Truth *below.*
In Schools, *I hold* Theorick *Knowledge good;*
I' th' World, *it leads our* Senses *in a* Wood.
The active Soul *takes nothing upon* Trust,
But proves its Truth: *while duller* Wights *in* Rust
And Sloth *consume their* Time: *Their* empty Faith
Believes *all* true, *whatever any saith.*
Thus Three parts *of the* World (*in Error grown!*)
'Gainst Practick-knowledge *vouch* Opinion.
Had brave Columbus *worn so poor a* Soul,
Or bold Americus *a* Brain *so* Foul,
Or Noble Cabot *of that* Temper *been,*
The Indies *to this* Day *had not been* seen
By brisk Europeans! *Whereas now the Name*
Of Worthy Columb, *gives the* Spaniards Fame;
Americus *the* Portugals; *and* Cabot *yields*
Stout Albion *Honour, all its* Glories guilds.
Who breaks the Ice *in any* Great Design,
(*And happy Actions unto Judgement join*)
Deserv's to wear *their* Countries *brighter* Bays!
Who Perfects *it, merits* Immortal Praise.
Then thank *our painful* Author, *thus imparts*
Unto the World *his* choice *and* dear-bought Arts;
Whereby our ruder Understandings *may*
Gain Knowledge *in the* Mathematick *way:*
No Spot on Earth, *no part of* Sea *or* Sky,
But by this Book *Men may* learn *to* Survey.
Horologia *(an Art so highly priz'd,*
And by some Nations *almost* Idoliz'd!)
Is here *so* plainly *taught, that* Vulgar Men
May Dials *make, although they scarce know* Pen.
Now Hogen-Friar's *Skill must be laid by,*
It's far out-done *by th'* Author's Gunnery.
Merchants *and* Sea-men *here their* Customs *learn,*
Their Juster Laws *from* Tyranny *discern.*
No Book *so* comprehnsive *in our Tongue*
As This. *But lest my ruder* Lines do wrong,
I will retire, and leave That *to its* Fate,
Which I fore-see *will be* most Fortunate.

John Gadbury, Φιλομαθηματικὸς.

A FRIENDLY ADVERTISEMENT TO THE Navigators and Mariners of ENGLAND.

BRETHREN,

THe Duties of a Friend and the Properties of a Flatterer do differ ſo greatly, that a Man cannot perform the Office of the one, but he muſt renounce the Practice of the other; And a very Fountain it is, from whence many Miſchiefs do ſpring and overflow the wretched Life of Mankind, that the true dealing of Friends is moſt commonly unpleaſant and hateful; but the ſoothing of Flatterers is become plauſible, and much ſet by: In reſemblance they bear many times like ſhew; but in purpoſes they always differ. A true Friend will ſometimes commend and praiſe divers things in his Friend; and ſo will alſo the Flatterer, in thoſe whom he followeth. The one commendeth that which in Judgment he thinketh commendable, to the end that his Friend ſhould ſtill proceed in Actions worthy of Commendations; the other commendeth even thoſe things many times which in his heart he doth deteſt, to the end that he may ſooth up the Humour of the Party. A faithful Friend, what he diſallows in his Judgment of his Friend, he will be earneſt with him to ſee the fault, to the end the Party may amend, and give no advantage to his Enemy: The Flatterer ſometimes, though ſeldom, will alſo diſcommend, but evermore trifling matters; fearing to offend the Party, if he ſhould touch him; ſo counterfeiting ſincere Love (the Badge only of true Friendſhip) and ſo leaveth the Party, thus abuſed, to the ſcorn and reproach of the Adverſary, reaping the Commodity which he looked for, as the only end of his deſire.

I do not think that there is any Man, that either regardeth Gods Glory, or eſteemeth of Humane Society, but holdeth our Art worthy to be numbred with the moſt excellent that are exerciſed among men; and therefore it is great reaſon the Practicers of it ſhould be had in greater reputation than they be now adays. Neither is there any other Art wherein God ſheweth his Divine Power ſo manifeſtly, as in ours; permitting unto us certain Rules to work by, and increaſing of them from time to time, growing ſtill onwards towards perfection, as the World doth towards its end; and yet reſerveth ſtill unto himſelf the managing of the whole, that when we have done what we can, according to the Skill we have already, or may have by any thing that we may learn hereafter, yet always will God make it manifeſt, That he alone is Lord and Ruler of Sea and Land; That all Storms and Tempeſts do but fulfil his will and pleaſure, who oftentimes adminiſtreth many helps, beyond all expectation, when the Art of Man utterly faileth; which is lively expreſſed in *Pſalm* 107. where is nothing omitted which is neceſſary, nor any thing affirmed but that which the continual experience of our daily dangers do proclaim to be true.

O that we that ſee his wondrous Works in the Deep, would therefore praiſe the Lord for his Mercies, and ſhew forth his Wonders before the Children of Men; that we might once learn, That the Fear of the Lord is the beginning of Wiſdom. Moſt undoubtedly then would our Art flouriſh, our Voyages proſper, and have better ſucceſs; yea, our ſelves would be more eſteemed and honoured of all men. Whereas now the profane Lives, and brutiſh Behaviour of too too many of our Trade, doth ſomewhat eclipſe the Glory of the Profeſſion it ſelf. Beſides other manifold puniſhments, God ſtriketh ſome of us with the Spirit of Blindneſs, as no men living, of any Trade whatſoever, are to be found ſo ignorant as many of us are: ſo ſenſeleſs are we in our own defects,

ſo

ſo little deſirous to amend them, Yea, and ſome of us of the greateſt Skill and Practice are ſo loth to give God his due Glory, that many times labouring to ſuppreſs it, we make Shipwreck of our own Credits and Reputations, which otherwiſe of right might accrew unto us. When we have performed a long Voyage, of great difficulties, wherein many a time and oft we have been at our wits end, and knew not which way in the World to turn our ſelves, God delivering us beyond our expectation, as our Conſciences can witneſs; yet when the danger is once paſt, and that home we be come, we take it as a blemiſh of our Eſtimations, and a great Impeachment to our Credits, to give God the Praiſe, and yield him Thanks; imagining that would derogate too much from the Admiration which we ſo greedily hunt after among Men. But let me give you one Example of this Ingratitude to God, on a Voyage from the *Weſt-Indies*, in the *Society* of *Topſham*, a Ship that I had command of. It pleaſed God by a violent Storm and Sea, 500 Leagues from *England*, we loſt all our Maſts, and were ſeveral times like to founder our Ship: It pleaſed God that little Proviſion we made for Sail, and the miſchievous Storm continuing, turned to our good; for the Wind was fair, but the Sea ſo dangerous and grone, that we could not Scud or Sail but ſometimes; but in good time it brought us ſafe into the foreſaid Harbour of *Topſham*. And in our diſtreſs our Men were very mindful of Prayer, as all are; but coming to our deſired Port, I deſired them to return our gracious God Thanks, with me, for our great Deliverance: Some were willing, but two refuſed; whereupon I told them, *That when they were next in diſtreſs, it may be God would refuſe them help or deliverance*: And ſo it fell out; for *William Witheridge* of *Kenton* in *Devonſhire* was drowned at *Bilboa* the next Voyage following, and the other was drowned at *London*. Therefore let me adviſe all, to have a care not to be ungrateful to God.

We of this Nation are toomuch given to admire Strangers, and contemn our own Country-men.

There are many men that perform long Voyages God knoweth how, but not they themſelves; yet will ſwear and ſtare, crack and boaſt, That they have done all things according to Art; and tell a Tale to Strangers at home, of ſuch Gulfs and ſwift Currents, more than ever God made, to ſhadow their Ignorance, and rob God of his Praiſe: But yet for the Navigators and Mariners of *England*, I do hope and verily believe in my Conſcience, That divers of them do fear God unfeignedly, and do as much diſlike the diſſolute courſe of the common ſort, as any men can: And I do nothing doubt, although the number of ſuch are too few in our Nation, yet are they more than any Nation in the World can ſhew beſides. However, two things are greatly wiſh'd by all our Well-willers; An Increaſe in us of the true Fear of God, and a careful Diligence in us in things belonging to our Art. Where the Fear of God is not, no Art can ſerve the turn; for that were to make of Art an Idol: And yet all thoſe that fear God, muſt take heed that they do not tempt God; and therefore ought they to uſe Art, as the means that God hath ordained for their benefit, and be thankful unto him for it. *Farewel.*

Yours,

From my Houſe and Study at St. Georges, *or* Pill, *neer* Briſtol, *November* 12. 1667.

SAMUEL STURMY.

Errata.

ERRATA.

Courteous Reader,

IN a Work of this Nature it is impoſſible to eſcape Miſtakes, the which Man-kind could never totally evade ſince the firſt lapſe of his Great-grandfather Adam. *I hope I ſhall obtain your pardon therefore, though this preſent Tract hath ſome few Typographical Errors, which yet are not many, nor conſiderable, though the Author were far remote from the Preſs all the while. I have here given thee notice of as many as I could here readily eſpy; If thou findeſt any other, I deſire thy favourable Cenſure, and that thou wouldeſt correct theſe in manner following.*

In the Firſt, Second, Third, and Fourth Books.

Page 56. line 3. for *when I at Sea*, read *were I at Sea*. l.35. for *baſt of* r. *bawl aft*, p.19.l.22. for *all* r. *bawl* l.35. for *therefore* r. *the fore*, l.41. for *Maſt* r. *maſt*, p.18.l.5. for *laught* r. *taught*, l.45. for *laught* r. *taught*, p.19. l.3. for *Private* r. *Privateer*, p.20 l.17. for *Guas* r. *Gunner*, p.34.l.6. for *flat* r. *flat*. p.54 l.10. for *inexted* r. *invexed*, p.61.l.10. in the Table of Sines againſt 40 m. put in 112, p.140.l.4. for *firſt* r. *fifth*, p.145. the laſt Courſe but one upon the Log-board, for *S E, B* r. *S E, L*; the laſt Courſe on the Log-board, for *S E 9 knots* r. *S E 0 knots*, p.146.l.47. for *the wind at W S W and E S E* r. *the wind at S S E and S S W the Ship made Leeward way*, p.147. in the Table, at the fifth Courſe, for *N by W* r. *N N W*, p.160.l.52. for *N S* r. *N E*, p.162.l.3. for *Arabically* r. *Analytically*, p.174.l 46. for *51 deg.* r. *51 parts*, p.117.l.4. for *legree* r. *degree*, p.195.l.46. for *20 deg. of Longitude* r. *20 deg. 30 m. of Latitude*, p.200.l.38. for *let* r. *ſet*.

In the Fifth and Sixth Books.

P.2.l.44. for *Veraſtey* r. *Peraſtor*, p.4. the Square *A B C D* ſhould be a Geometrical Square of equal ſides, p. 7,8,9. ſome figures in the Sums of Diviſion are ſet out of order, p.24.l.11. for *retraſt* r. *pretraſt*, p.80.l.23. in marg. for *having done* r. *hanging down*, p.103.l.1. for *convex* r. *concave*.

In the Seventh Book.

In tit. p. for *Gnomical* r. *Gnomonical*, a.1.l.5. for *Gnomical* r. *Gnomonical*. p.8.l.23. for *C H* r. *C G*, p.12. in the Dial there wants the letter *E* toward the top of the Stile, p.13. this ſhould be added to Chap. 8, for the North and South erect Dial.

To Calculate the Hour-Lines.

As the Radius,
To the Stiles Height 38 d. 30.
So the Tangent of the Hour,
To the diſtance from the Meridian.

Hours.	Stile 38 deg. 30 min.			
	Angle of the Hour.		Arch on the Plane.	
	d.	m.	d.	m.
12	0	0	0	0
1	15	0	9	28
2	30	0	19	54
3	45	0	31	54
4	60	0	47	9
5	75	0	66	42
6	90	0	90	0

p.18. in the Figure, *C* is wanting in the Center, p.19.l.7. for *B* r. *H*, and ſome ſmall Letters are wanting in the Hour-Scale. p.23.l.7. for *F W* r. *E W*, l.8. for *continue* r. *contain*, l.21. for *third Point* r. *three Points*, p. 28. l.1. for *F L e* r. *F L e*, p. 30 *P* is wanting at the edge of the Stile, p.31. l.34. for *et* r. *as*, for *F O R C Q* r. *F O R e Q*, p.34. in the Dial, for *e* r. *C*, p.40. in the Dial, the Letter *I* is wanting at the Interſection of the Line *F R A* with the Hour-line of 5. p.40. l.14. for *R* r. little r. l.16. for *E R* r. *E r*, p.41. in the Dial, for *K* make *B*. p.43. in the Dial, for 4 make *q*.

I thought Good to advertiſe thoſe that have occaſion for any Inſtruments mentioned in this Book, or any other for the Mathematical Practice, either in Silver, Braſs, or Wood, they may be exactly furniſhed by Mr. *Walter Hayes* at the *Croſs-daggers* in *Moor-fields*, next door to the *Popes Head* Tavern, where they may be furniſhed with all ſorts of Carpenters Rules, Poſt and Pocket Dials for any Latitude, at reaſonable Rates.

THE

THE

AUTHOR

Implores Aid of

GOD'S EVERLASTING FOUNTAIN.

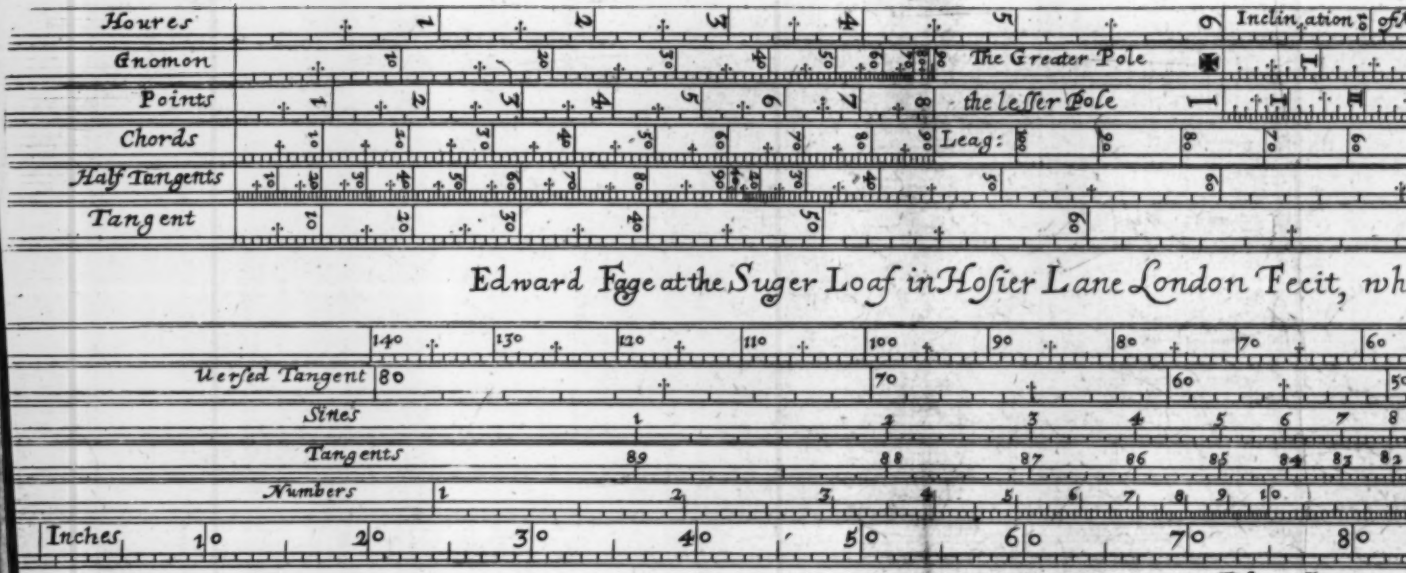
OH! All-sufficient Fountain, Lord of Light,
Without whose gracious Aid and constant Sprite
No Labours prosper, howsoe're begun,
But fly like Mists before the Morning-Sun.
O, raise my Thoughts, and cleer my Apprehension;
Pour down thy Spirit on my weak Invention:
Be thou the Load-star to my wandring Mind,
New rigg'd, and bound upon a new Design;
O, fill my Canvas with a prosperous Wind,
Grant that of thee I may Assistance find:
So bless my Talent with a fruitful Loan
That it at least may render Two for One.

THE

The chief Profeſſions now [illegible] out envy be it ſpoken, we may as well live as the ancient *Romans* without Phyſicians, and as honeſt Neighbours without Lawyers, better than without skilful *Seamen*, which are the chief *Importers* of our Wealth, and *Supporters* of our Warfare.

Beſides that, of all Mathematical Sciences and Arts profeſſed in the Univerſities, of this Art of *Navigation* is made the moſt general and profitable uſe; for what can the Scholar make of his *Geometry*, with all the nice and notional Problems thereof: or of *Aſtronomy*, with all his curious Speculations about the motion of the Planets, without they be applied to ſome more Mechanical and Practical Arts, as *Coſmography*, *Geography*, *Surveying*, *Dyalling*, *Architecture*, *Military Employments*, which ſhall in ſome meaſure (ſufficient for the help of Mariners) be ſhewn in the following Treatiſe, wherein it will appear, That the Art of *Navigation* comprehends them all in the uſe thereof?
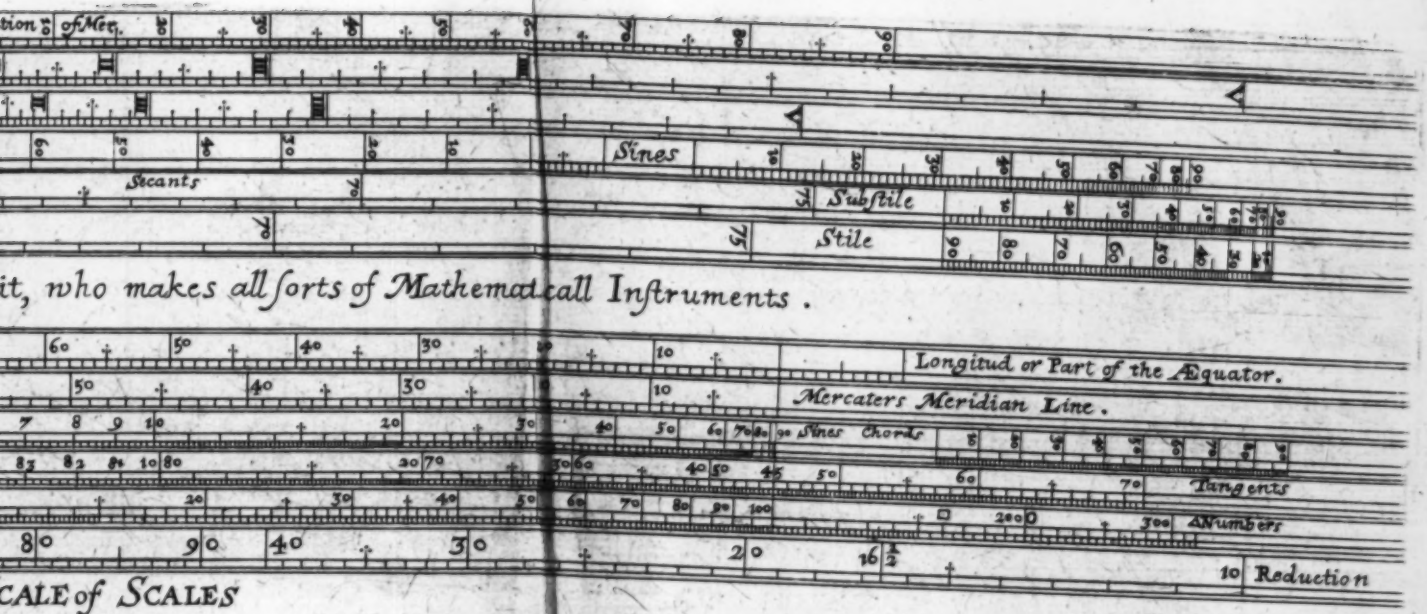
And thoſe that will be compleat *Sea-Artiſts*, had need to endeavour to have ſome skill and underſtanding in moſt of theſe Arts, namely, the Theorick and Practick parts, whereby they may be fully informed of the Compoſition of the *Sphere* in general; and in particular for the *Figure*, *Number*, and *Motion* made in the Heavens by



Edward Fage at the Suger Loaf in Hosier Lane London Fecit, wh

The SCALE o

These Naturall and Artificiall Scales are described at large with their Fundamentall Diagrams
Mathematicall conclusions, with many other Instruments, the makeing and necessary



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THE

The Compleat MARINER, OR NAVIGATOR.

The First Book.

CHAP. I.

The Argument or Deſcription of the Art of Navigation *in general.*

NAVIGATION of all Arts and Sciences (ſetting *Divinity* aſide) hath much reaſon to have the preheminence, it being of ſuch neceſſary and publick Concernment; and what uſe there is made of it by *Seamen* at this preſent, as well as hath been in times paſt, All men know, to whom the Countries are beholden for their good Service, whoſe Courage hath kept *Great Britain*, *Queen* and *Regent* of the Sea, and deſerves it well, in reſpect of the Skill and Valour of her Mariners, and Goodneſs and Number of her Ships. I wiſh as long as the Sun and Moon endures, That they may maintain their Courage, and improve their Art, as they ever have, againſt all Nations that have been *England*'s Enemies; and ever may they crown their Undertakings with everlaſting Credit.

The Art of *Navigation* being ſuch, I think I may be bold to affirm without preſumption, This Art is more neceſſary for the well-being and honour of our Nation, than any other Art or Science Mathematical, which is more carefully kept in the Univerſities. Look upon *Grammar*, *Rhetorick*, and *Logick*, theſe are but Introductions to other Arts; *Muſick* is but of little uſe.

The chief Profeſſions now in the Univerſities are *Phyſick* and *Law*. Without envy be it ſpoken, we may as well live as the ancient *Romans* without Phyſicians, and as honeſt Neighbours without Lawyers, better than without skilful *Seamen*, which are the chief *Importers* of our Wealth, and *Supporters* of our Warfare.

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And thoſe that will be compleat *Sea-Artiſts*, had need to endeavour to have ſome skill and underſtanding in moſt of theſe Arts, namely, the Theorick and Practick parts, whereby they may be fully informed of the Compoſition of the *Sphere* in general; and in particular for the *Figure*, *Number*, and *Motion* made in the Heavens by

the higheſt Moveable called *Primum Mobile*, and likewiſe of the firſt, fourth, eighth, and ninth Heavens. It will alſo inform them how the Elements are diſpoſed, with their quantities and ſcituations, eſpecially in the Compoſition of the Sphere of the World, which is commonly underſtood to be the whole Globe of the Heavens, with all that therein is contained; which is divided into two parts, *Elemental* and *Cæleſtial*. The *Elemental* hath again four parts, *viz.* The firſt is the *Earth*, which together with the *Water*, as the ſecond, maketh a perfect Roünd Globe, whereupon we dwell; therefore the Nature and Circles which are ſuppoſed to be contained in that *Sphere*, are fit to be known. The next is the *Air*, comprehending the *Earth*; and the fourth the *Fire*, which according to the opinion of Philoſophers containeth the ſpace which is between the Air and the Heavens, or Circle of the Moon. Out of theſe Elements, which are the beginning of all things that are ſubject to change, together with the warmth of the Heavens, all things do come forth, and decay, as we ſee and find upon the Earth, by the continual Change and Motion of the One into the Other.

The *Cæleſtial* part (containing within the concavity thereof the *Elemental*) is tranſparent and perſpicuous, ſhining, ſevered, and free from all mutability; and is divided into eight *Spheres*, or round hollow Globes, which are called Heavens, whereof the greateſt doth contain the next unto it Globe-like; the ſeven Inferior have in each of them but one Star or Planet only, whereof the firſt (the next to the Earth) is the Heaven of the *Moon*; The ſecond of *Mercury*; The third of *Venus*; The fourth of the *Sun*; The fifth of *Mars*; The ſixth of *Jupiter*; The ſeventh of *Saturn*; And the eighth of all the *Fixed Stars*. The number of theſe *Heavens* are known by their Courſes round about the *Poles* of the *Zodiack*. The *Moon* runneth through her Heaven by her Natural Courſe from the *Weſt* to the *Eaſt* in 27 days 8 ho. *Mercury*, *Venus*, and the *Sun*, their courſe in a year, and ſome leſs than a year; *Mars* his courſe in two years, *Jupiter* in 12, and *Saturn* in 30 years; The Eighth Heaven, according to the Obſervation of *Tycho Brahe*, in 25400 years.

Theſe *Heavens* are carried all together in 24 Hours upon the Poles, about the Axle-tree of the World thorow the ninth Heaven, by vertue of the *Primum Mobile*, that is, the Firſt Moveable; by which Motion to our appearance is cauſed the Day and Night, and the daily Riſing and Setting of the Cœleſtial Lights; But more of this in another place, for here I have made a Digreſſion. So that no Art is more capacious; and were the Excellency well underſtood, and put in practice, as it might be (as Mr. *Philips* ſaith in the like caſe) no Employment would be more honourable and advantageous for the moſt generous Gentleman, and Learned Student, than this of *Navigation*; thus it was in eſteem in the days of Queen *Elizabeth*,

When Drake *and* Candiſh *Sayl'd the World about,*
And many Hero's *found new Countries out,*
To Britain's *Glory, and their laſting Fame;*
Were we like-minded, we might do the ſame.

The Practick part of *Navigation* is properly placed in making and uſing of Inſtruments, which is ſhewn in the ſecond Book. Yet there is a certain Compoſition in the Practick, more rare than all the reſt, in the compleat Sea-Artiſt; and that is the right Words and Phraſes uſed in guiding, governing, and conſtraining, to perform the expert Navigator's pleaſure in the Sea; In ruling the unparallell'd Fabrick of a gallant Ship, which hath been omitted by moſt men that have writ of this Art; therefore I ſhall explain it with my Pen, becauſe I know with proper Phraſes how to perform it, not hindring any other, as they not me, to ſhew truly and lively their Skill in controlling, guiding, and working a Ship, according to all Weathers at Sea; although it be of no uſe to Sea-men, that have been all their life-time at Sea: but for Gentlemen on Shore to read for their Recreation, the Words of Command at Sea, which may be delightful unto them. But for experienced Sea-men, they have all thoſe things imprinted in them, and make uſe thereof according as their buſineſs ſhall fall out at Sea, but after the ſame manner.

In regard all Arts and Sciences are divided into two principal parts, that is, the *Theorick* and *Practick*, I tooke upon me to demonſtrate according to my ability, which

which will give the moſt reaſonable men ſatisfaction; for the unreaſonable, I care not a fig for them; for I know it to be impoſſible for any man to be a compleat Sea-man, wherein this Knowledge is wanting, they being both inſeparable Companions which always wait upon *Perfection*. I ſhall draw out the Deſcription in as ſmall a compaſs as it can be, and haſten to the moſt material Practice.

CHAP. II.

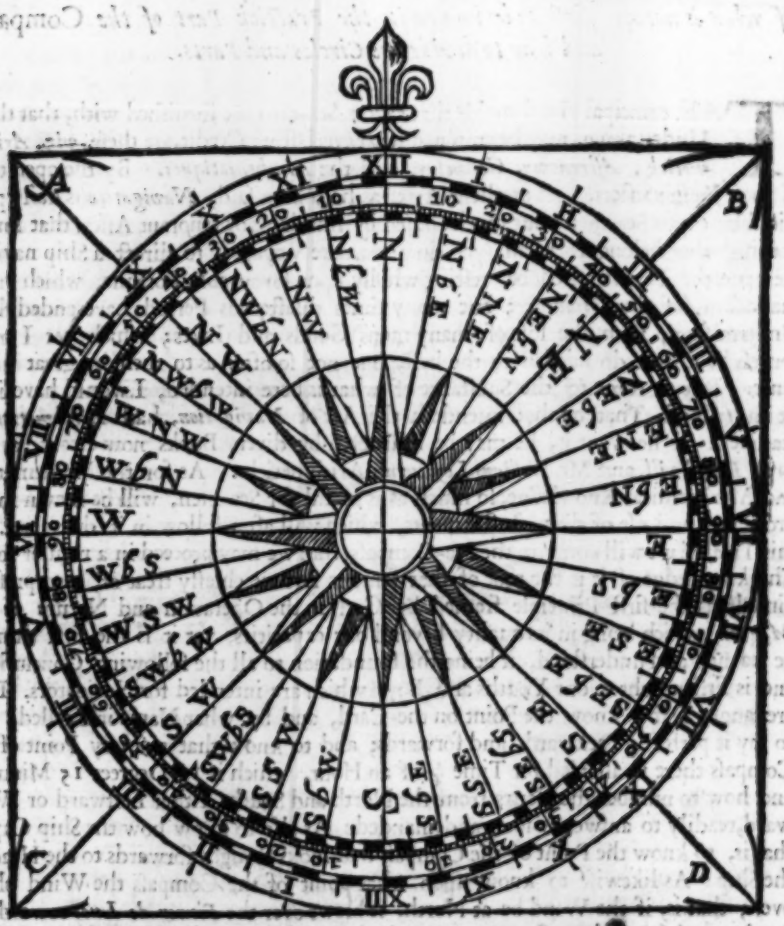
Of what is needful firſt to be known in the Practick Part of the Compaſs, *and how to divide the Circles and Parts.*

THE principal Hand-maids that expert Sea-men are furniſhed with, that their Undertakings may be crowned with everlaſting Credit, are theſe, *viz. Arithmetick*, *Aſtronomy*, *Geometry*, and the *Mathematiques*. By the operation of theſe loving Siſters, and excellent Arts, as hath been ſaid, *Navigation* is daily practiced by expert Sea-men: but much abuſed by hundreds of ignorant Aſſes, that know nothing what belongs to them, yet do undertake Voyages, to direct a Ship navigable upon the Terreſtrial Globe, reſting wholly upon favourable Fortune, which hath made ſome of them famous; but many times diſaſterous Periods have ended their Undertakings, with the loſs of many mens Goods and Lives; which yet I muſt confeſs have and do happen to the beſt, but not ſo often as to them by great difference. But to come to the Subſtance of what is here intended, I would have it to be underſtood, That he that intendeth the Art of *Navigation*, hath *Arithmetick* in readineſs. If he want it, he may be inſtructed by divers Books now extant, as *Record*, *Mandevill*, and Mr. *William Leybourn*'s Arithmeticks. As for the Mathematical and Aſtronomical Knowledge, ſo much as is uſeful for Sea-men, will be ſhewn in the Projection and uſe of divers Inſtruments, which will after follow in its due place. In this Treatiſe we will come to the Sea-Compaſs, that we may proceed in a regular form. The knowledge of it is the root of that famous Art we chiefly treat of, and preſents himſelf as the firſt Principle framed by God in the Operation and Nature of the *Magnet*, which being in its quality beyond our capacities, yet it is the firſt thing to be learned and underſtood, it being the foundation to all the following Concluſions, and is firſt taught to our Youths and Boys which are intended for Navigators. They are taught firſt to know the Point on the Card, and by what Name it is called, and to ſay it perfectly backwards and forwards; and to know that to every Point of the Compaſs there is allowed for Time $\frac{1}{4}$ of an Hour, which is 11 Degrees 15 Minutes; and how to number the Hours from the North and South, either Eaſtward or Weſtward, readily to anſwer as ſoon as demanded: As alſo to know how the Ship Capes; that is, to know the Point of the Compaſs that looks ſtraight forwards to the Head of the Ship: As likewiſe to know upon what point of the Compaſs the Wind blows over; that is, if the Wind be at North, it blows over the *Flower de Luce* toward the South; and ſo of the reſt. So we teach them to know what Point the Sun is on; That in *England* a South-eaſt Sun on the *Æquator* makes 9. 24 of the Clock; and when he is South, makes 12 of the Clock; and South-weſt, 2. 36 of the Clock. As alſo they learn to ſet the Moon in the ſame manner on the Full and Change-days, to know the Tides by, as ſhall be ſhewed.

The Compaſs we Steer our Ships by, is only a Circle of ſome 8 inches diameter; and is divided into 32 Points, which have ſeveral denominations, as you may ſee expreſſed in the Figure. The whole Circle is divided into 360 degrees, and 24 hours. The Compaſs contains alſo 16 diſtinct Rhombs or Courſes; for each ſeveral Courſe hath two Points of the Compaſs, by which it is expreſſed. As for example, Where there is any place ſituated South-eaſt, in reſpect of another place, we ſay the Rhomb or Courſe that runneth betwixt them, is South-eaſt and North-weſt: or if it bear South or North, ſo we call it: or if Weſt, we ſay Weſt and Eaſt. The Compaſs ſwings in the Boxes, the Wyers firſt well touched with a good Load-ſtone, and the Chard ſwimming well on the Pin perpendicular in the middle of the Box; it repreſents

ſents the plain Superficies or *Horizon* as we call it, when looking round about us at Sea, and ſee the Heavens make interſection with the Waters, ſheweth that you are in the Center, and that every place in the *Horizon* is equally diſtant from you: So that when you eſpy any Iſland, Rocks, Ships, or Cape-Lands, by looking ſtraight upon the Compaſs, you ſhall know upon what Point of the Compaſs the Object beareth from you. But we will haſte to ſhew the young Practitioners the Sea-Compaſs, with the 32 Points, expreſſed by the Letters upon each Line, and alſo how to make it, as followeth.

The COMPASS.



How to divide the Circles *of the* Mariners Compaſs.

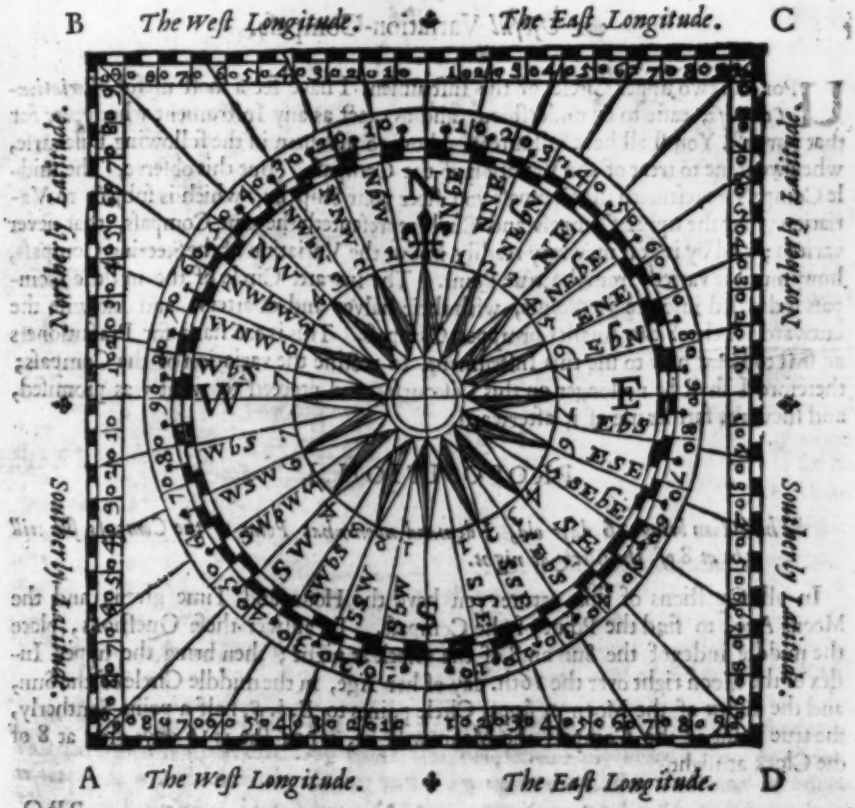
FIrſt draw a Line at pleaſure, and croſs it in the midſt with another Line at right Angles; Then in the croſſing of theſe two Lines ſet one foot of your Compaſs, and open the other to what diſtance you pleaſe, and with that diſtance draw the Circle, which by the croſs Lines of *Eaſt* and *Weſt*, *North* and *South*, are divided into four Quadrants and equal parts, each of them containing 6 hours apiece; ſet VI at *Eaſt* and VI at *Weſt*, XII at *North*, and XII at *South*, ſo have you the four firſt Diviſions of your Figure: Then keeping your Compaſs at the ſame diſtance as you drawn'd the Circle, ſet one foot in the croſſing of the Line and the Circle at *Eaſt* 6, with the other make two marks, one of II, and X. Then ſet one Foot in the *Weſt* at 6, on the other ſide mark out the hours of II and X, as before; keeping the Compaſſes ſtill at the ſame diſtance, ſet one Foot at South XII, and with the other you ſhall mark out the Hours of VIII and IIII. Then ſet one Foot of your Compaſſes at *North* at XII, and in the ſame manner mark out the Hours of VIII and IIII. Thus the Circle is divided into 12 equal parts, and each of them contains 2 hour apiece;

piece; ſo that it will be eaſie for you to divide each of theſe into two parts; which done, you have the 24 hours. Laſtly, you may divide each hour into 4 equal parts, which will be quarters of an Houre, as you may ſee in the Figures.

To divide a Circle into 360 equal parts, is a thing very neceſſary; for in all Queſtions in *Aſtronomy*, and in the Calculation of all *Triangles*, theſe parts are the meaſure of the Angles: ſo that in reſpect of this, every Arch is ſuppoſed to be divided into 360 equal parts or Degrees; and every Degree is ſuppoſed to be divided into 60 leſſer parts, called Minutes. To divide a Circle after this manner, draw a Line at pleaſure, and croſs it at right Angles with another Line, and draw a Circle as before. Keep your Compaſſes at the ſame diſtance, and divide the Circle from the 4 Quarters into 12 equal parts. Then cloſing your Compaſſes, divide each of theſe into 3; ſo you have in all 36 parts. Then you may eaſily divide with your Pen each of theſe parts into 10 little parts, as you may ſee in the middle Circle of the Figure, which are Degrees.

For the 32 Points of the *Compaſs*, draw the Line of *North* and *South*, and croſs it at right Angles with the Line of *Eaſt* and *Weſt*, and draw the Circle, as before; and with the ſame diſtance, ſet one Foot of your Compaſſes at *Eaſt*, and with the other draw a ſmall Arch at A and B, and croſs it from *North* to *South* with the ſame diſtance; the like do from the *Weſt* Point to C and D. Then laying your Rule croſſ-ways to theſe Croſſes, draw the Line B D and A C; ſo is your Circle divided in 8 equal parts. Then cloſing your Compaſſes, you may eaſily divide theſe 8 parts into 4; divide one, and that diſtance which will divide all the reſt into equal parts, if you have followed Directions. And ſo you have the 32 Rhombs or Points of the Compaſs; and ſo you may ſubdivide theſe Points into halves and quarters, as you may ſee in the Figure. So have you made the Mariner's Sea-Compaſs. The Uſe ſhall be ſhew'd in its place.

The Figure of the Compaſs, *and the* Traverſe Quadrat, *joyned both together.*



The *Traverſe Quadrat* ſheweth the making of the *Traverſe Table*, in *Chap.* 3. Of Sayling by the plain Sea-Chart.

The

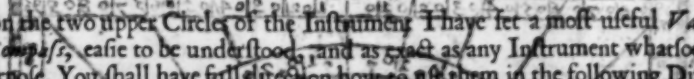
The Moons *Motion, and the Ebbing and Flowing of the* Sea.

THe Practitioner in *Navigation*, is next to learn to know the certain time of the Flowing and Ebbing of the Sea; In all Ports called by Sea-men the ſhifting of Tydes, which is governed by the *Moon's* Motion, as it is found by experience.

Wherefore I will firſt ſhew the uſe of a ſmall Inſtrument, which is here framed, whereby the meaneſt Capacity (which is void of *Arithmetick*) ſhall be able to know the Age of the Moon, with what Flood and Ebb it maketh in all Channels, and in every Port and Creek at High-water; and alſo be able to know what a Clock it is at any time of the Night; and divers other Queſtions, only by moving the Inſtrument, according as ſhall be directed.

I ſhall alſo ſhew you, how you may do all theſe Queſtions of the Tyde by the Moon Arithmetically: But firſt by your Inſtrument it muſt be projected according to the following Figure, which you may make of three pieces of Board, well planed, and exactly divided, according as you ſee it formed in the Figure. The outward Circle, being the biggeſt Board, hath 32 Points of the Compaſs; The inward Circle on the ſame Board is divided into 24 Hours, being the thickeſt Board. The ſecond Circle muſt be divided into 30 equal parts, repreſenting the diſtance 30 times 24 Hours, or 30 natural days, attributed to the Sun. The uppermoſt Circle of the three, is attributed to the Moon, with an Index as that of the Sun, and to be turned and applied to either the 30 days, containing the Computation of the Moon betwixt Change and Change, or the 24 hours; as likewiſe to the Points of the Compaſs. And ſo may the Index of the Sun be applied either to Time, or the points of the Compaſs, which ſhall be made plain by the following Queſtions; which will appear delightful and eaſie; and the illiterate man will find in moſt uſeful; and he that hath better Knowledge, will ſometime uſe the Inſtrument for variety ſake. Firſt, for the Figure of the Inſtrument.

A Uſeful Variation-Compaſs.



UPon the two upper Circles of the Inſtrument I have ſet a moſt uſeful *Variation-Compaſs*, eaſie to be underſtood, and as exact as any Inſtrument whatſoever for that purpoſe. You ſhall have full direction how to uſe them in the following Diſcourſe, when we come to treat of the Variation of the Compaſs. But this obſerve, The middle Compaſs repreſenteth the Compaſs you ſteer your Ship by, which is ſubject to Variation; but the upper Compaſs and Circle repreſenteth the true Compaſs, that never varieth; and by it you may very readily know the Variation of the Steering Compaſs, how much it varieth from the true Point. The inward Circle of the middle Compaſs is divided into the 32 Points, with their halves and quarters: and likewiſe the outward Circle of the ſmaller or upper Compaſs. This is too hard for Practitioners at firſt to know how to uſe this Inſtrument, to rectifie the variation of the Compaſs; therefore I ſhall be no longer on this Diſcourſe, and proceed to what was promiſed, and ſhew the farther uſe of it afterward.

PROPOSITION I.

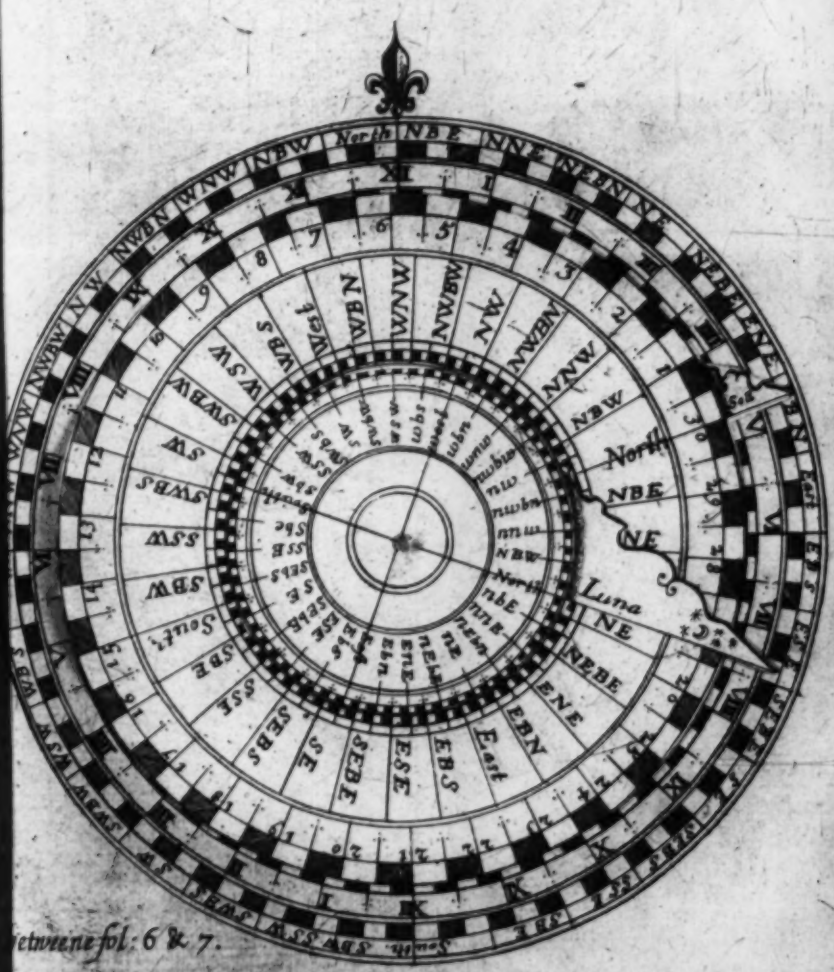
Here the Variation Compaſs is to be placed.

The Moon being 16 days old, I demand upon what Point of the Compaſs ſhe will be at 8 of the Clock at night.

In all Queſtions of this nature you have the Hour and Time given, and the Moons Age, to find the Point of the Compaſs. To anſwer theſe Queſtions, place the middle Index of the Sun on 8 of the Clock at night; then bring the upper Index of the Moon right over the 16th. day of her Age, in the middle Circle of the Sun, and the Index of the Moon or upper Circle points to *E. b. S.* half a point Southerly, the true Point of the Compaſs the Moon will be, when ſhe is 16 days old, at 8 of the Clock at night.

PRO-

An Instrument Shewing ye Changing of ye Tides and ye Variation of ye Compas



Betwene fol: 6 & 7.

PROPOSITION II.

The Moon being 16 *days old, I demand, what is the Clock when ſhe is upon the* S. E. *Point?*

In Queſtions of this nature, you have the Point of the Compaſs, as well as the Moons Age: therefore turn the Index of the Moon to the South-Eaſt Point; keeping the Index faſt to the Point, bring the 16th. day of her Age in the middle Circle, right under *Luna's* Index, and the Index of the Sun points and ſhews you 10 a Clock at night, that the Moon will be South-Eaſt.

PROPOSITION III.

The Moon being S. E. b. S. *at* 8 *of the Clock at night, I demand, How many days old ſhe is?*

In ſuch like Queſtions, you muſt firſt put the Index of the Moon to the Point of the Compaſs South-Eaſt by South, and the Index of the Sun ſet to the Hour of the Night; then look where the Index of the Moon cuts the Circle of Days, and you ſhall find it cut the 13th. day of the Moons Age required.

PROPOSITION IV.

The Moon being Eaſt-South-Eaſt, and the Sun Weſt-North-Weſt, I demand the Moons Age.

In all Queſtions of this nature, obſerve what you have given; then put the Index of the Moon to the *E. S. E.* Point, and hold it ſteady whilſt you put the Index of the Sun to Weſt-North-Weſt, and then look where the Index of the Moon cuts in the Circle of Days, and you ſhall find it cut the 15th. day of her Age, that is the Day ſhe was at the Full, and anſwereth the Queſtion deſired.

PROPOSITION V.

The Moon being 17 *days old, I demand the time of the Day ſhe will be Eaſt-North-Eaſt.*

In all theſe ſorts of Queſtions, Note, You muſt put the Index of the Moon to the Eaſt-North-Eaſt Point, ſtop it faſt there, and turn the Index of the Sun about until the 17th day of her Age is under the Index of the Moon; then look what hour the Index of the Sun is upon, and you will find it 6 a Clock and 5 Minutes paſt, which anſwers you the time of the Day required.

This is worth your Obſervation, That if the Index points to the Eaſtward of the North and South, it ſhews the morning 12 hours; if it points to the Weſtward of the North and South, it ſheweth the Evening 12 hours. Thus you ſee how ready the Practitioner in *Navigation* may have the Uſe of this Inſtrument, and by often practicing it, may be in a ſhort time ſo imprinted in his mind, that as ſoon as he hath occaſion to uſe it, he will be able to reſolve it by memory, which is an excellent Ornament to a young Mariner; Therefore let ſo much ſatisfie for the Uſe of the Inſtrument in ſuch like Queſtions.

PROPOSITION VI.

By the Inſtrument to find the time of Ebbing and Flowing, in any Port, River, or Creek.

Note. You are to obſerve juſt at the time of High-Tyde, what Point of the Compaſs the Moon is upon that Day which ſhe changeth, in any Port, River, or Creek, where you would know the Ebbing and Flowing of the Tydes, and time of High-Water or Full-Sea. This being found, you may know what Hour belongeth to

that

that Point of the Compaſs, by turning the Index of the Moon, as before was ſhewed: So you may be ſure to have the Hour always under the Index, on the Change-day, throughout all the Points of the Compaſs; and ſo we ſhall proceed to Examples.

PROPOSITION VII.

The Moon being 16 days old, I demand, What a Clock it will be Full-Sea at Briſtol, Start-point, Waterford, *where an East-by-South Moon on the Change-day makes the Full-Sea?*

You are to conſider the Point of the Compaſs the Moon is upon in theſe Ports, when it is Full-Sea on the Change-day (as in all other Ports) which in theſe Ports is found by obſervation to be always Eaſt-by-South Moon (which is 6 hours 45 minutes) Then conſider whether it be the Day or the Night-Tyde you would know the Time of Full-Sea; if it be the Morning-Tyde, bring the Index of the Moon to the Weſt-by-North Point, ſtaying it there; bring the 16th. day of her Age under the Index of the Moon, and the Index of the Sun will point you to 7 of the Clock and 33 Minutes, the time of Full-Sea in the Morning. If it be the Evening Tyde, bring the Index of *Luna* to the Eaſt-by-South, and ſtay it there, until you have brought 16 Days and half under the Index of *Luna*, and the Index of *Sol* will point directly upon 8 of the Clock at Night, the time of Full-Sea in the aforeſaid Ports: Thus you ſee there is 27 Minutes difference in every Tyde in theſe Ports. So you may know in every other Port in the ſame manner, if you do as before-directed, and allowing half a day more for the Night-Tyde, by turning of it half a day further. And take this for a Rule, That the Moon betwixt Change and Full is ever to the Eaſtward of the Sun, and riſeth by day, ſtill ſeparating it ſelf from the Sun until ſhe be at the Full: Then after the Full, in regard ſhe hath gone more Degrees in her ſeparation than is contained in a Semicircle, ſhe is gotten to the Weſtward of the Sun (riſing by night) and applieth towards the Sun again until the Change-day, which you may ſee plainly demonſtrated by the Inſtrument.

PROPOSITION VIII.

The Moon being 16 days old, I deſire to know at what hour it will be Full Sea at London, Tinmouth, Amſterdam, *and* Rotterdam, *where a S. W. and N. E. Moon makes a Full-Sea upon the Change-day.*

It is found by obſervation, That the S. W. and N. E. Moon makes Full-Sea in all the aforeſaid Ports. You may know the Moon is to the Eaſtward of the Sun that is before him; Bring the Index of the Moon to the S. W. Point; then turn the 16 day of her Age under the Moons Index, and the Index of the Sun anſwereth the Queſtion, That it is Full-Sea at all the aforeſaid Ports at 3 of the clock and 48 minutes in the morning, the Moon being 16 days old.

PROPOSITION IX.

At Yarmouth, Dover, *and* Harwich, *where a S. S. E. Moon maketh Full-Sea on the Change-day, the Moon being 9 days old, I demand the time or hour of Full-Sea that day in the aforeſaid Places.*

Here it hath been found by experience, That a S. S. E. Moon makes Full-Sea on the Change-day, in the aforeſaid places; therefore bring the Index of the Moon to the S. S. E. Point, keep it there faſt directly on the Point, and bring the Moons Age to cut the edge of the Moons Index, and the Index of the Sun will ſhew you, That the time of Full-Sea in the aforeſaid Ports, will be at 5 a Clock and 42 minutes in the morning.

PROPOSITION X.

At St. Andrews, Dundee, Liſbone, *and St.* Lucas, *where a South-Weſt-and-by-South Moon makes High-Water or Full-Sea on the Change-day; The Moon being 28 days old, I demand the time of Full-Sea that day in theſe Places.*

You

You have here given you the *S. W. b. S.* Point of the Compaſs; therefore bring the Index of the Moon, and ſtay it on that Point, and bring the 28 day of her Age under the edge of the Index of the Moon, and the Index of the Sun will point you out the time of Full-Sea, which is at 39 minutes paſt 12 of the clock at noon, in the aforeſaid places. And ſo are all Queſtions of this nature anſwered. And ſo I will conclude the Uſe of this Inſtrument, for finding the Ebbing and Flowing of the Tyde, and ſo will proceed to ſhew you Arithmetically how to find the *Golden Number* or *Prime* without a Table, the *Epact*, and *Full*, *Change*, and *Quarters* of the *Moon*, and how to know her *Age* for ever; and what *Sign* and *Degree* ſhe is in the *Zodiack*, how long the *Moon* ſhineth, and what time of the day or night it is High-Water or Full-Sea in any Port; and alſo the *Moon's* Motion, as far as it is uſeful for Mariners.

How to find the Golden Number *or* Prime, *according to the* Julian, Engliſh, *or Old Account.* I.

YOu may obſerve this, That the *Prime* or *Golden Number* is the ſpace of 19 years, in which the *Moon* performeth all her Motions with the *Sun*: At the expiration of which Term, ſhe beginneth again in the ſame *Sign* and *Degree* of the *Zodiack*, that ſhe was 19 years before; and always finiſheth her Courſe with the *Sun*, and never exceedeth that Term. To find this uſeful Number, you muſt do thus; Always in what year you would know what is the *Prime Number*, add 1 to the date thereof, and then divide it by 19, and that which remaineth upon the Diviſion, and cometh not into the Quotient, is the Number required. As for example,— In the year of our Lord 1665. I demand what is the *Prime Number*. Add to the year of our Lord always 1, which makes in this Queſtion 1666. Then divide that ſum by 19, the remain is the *Prime* or *Golden Number*, as you may ſee by the Work, which anſwereth the *Prime* or *Golden Number* for this preſent year to be 13, it being left out of the Diviſion that cometh not into the Quotient. Thus you ſee it is very eaſie to do it for any other year. Obſerve, That when you find nothing remaining upon the Diviſion, that is the laſt year of the *Moon's* Revolution, and may conclude, that 19 is the *Prime* for that year. Note, The *Prime* beginneth always in *January*, and the *Epact* in *March*.

1666 (87
299
x

How to find the Epact, *according to the* Julian, Engliſh, *or Old Account, and what it proceedeth from.* II.

THe *Epact* is a Number that proceedeth from the difference which is made in the ſpace of one whole year, between the *Sun* and the *Moon*. Note, The *Solar* year doth contain 365 days, 5 hours, 48 minutes; and the *Lunar* year, allowing 12 *Moons*, there being 29 days, 12 h. 44 min. between Change and Change, doth contain but 354 days, 8 hours, 48 min. So that there is almoſt 11 days difference between the Revolution of the *Sun* and *Moon*, at every years end; which difference makes the *Epact*. Therefore to find the *Epact* for any year, firſt you muſt know the *Prime Number* for that year, which we found before for the year 1665. to be 13. Then you muſt multiply this *Prime Number* 13. by the difference 11. and it will make 143. which divide by 30. and there remaineth of the Diviſion, that cometh not into the Quotient, 23. which is the *Epact* for the year required. So I make no Queſtion but that you underſtand how to find the *Prime* and the *Epact* for any year paſt, preſent, or to come. Therefore I hold this ſufficient to expreſs ſo facile a thing as this is. I have told you already, That the *Epact* always beginneth in *March*; but I ſhall make a ſmall Table for thoſe that are ignorant in *Arithmetick*, and cannot find theſe two *Golden Numbers*, as I may call them, for 45 years to come,

11
13 (2
33 (4
11
143

come, where any one may find the *Prime* and *Epact* moſt readily in any year you ſhall deſire.

III. *A Rule to find the* Change, Full, *and* Quarters *of the* Moon.

ADd unto the *Epact* of the year propoſed all the Months from *March*, including the Month of *March*, and ſubſtract that ſum from 30. the remain ſheweth the day of the *Change*: But if the *Epact* be above 26. there this Rule faileth a day at the leaſt; but at other times it will be no great difference: Therefore it may ſerve for the following Concluſions.

As for Example, I deſire to know the *New-Moon* in *October*, 1665. The *Epact* is 23. the Months from *March* are 8. which added makes 31. from it 30 ſubſtracted, remains 1. which taken from 30. one whole *Moon*, there remains 29. So that the 29th. day of *October* is the day of her *Change*, or *New-Moon*, which by exact Calculation it is at 58 min. paſt 4 in the morning.

Having thus found the time of the *New-Moon*, you may from thence reckon the *Age* of the ☽*Moon*, and ſo find the *Quarters*, or *Full-Moon*.

Thus the *Moon's Age* is	Days	Hours	Min.
At the Firſt Quarter	07	09	11
At the Full Moon	14	18	22
At the Laſt Quarter	22	03	33
At the Whole Moon	29	12	44

IV. *How to finde the* Age *of the* Moon *at any time for ever.*

ADd to the days of the Month you are in, the *Epact*, and as many days more as are Months from *March*, including *March* for one; and if theſe 3 Numbers added together exceed 30, take 30 from it as often as you can, and the remain is her *Age*: But if the Numbers added be under 30, that's her *Age*: As for *Example*, 1665. the *Epact* is 23. I demand, What *Age* the *Moon* is the 21th. day of *September*? From *March* to *September* is 7 Months, the *Epact* 23, and the day of the Month is 21. Added together, makes 51. From it ſubſtract 29, becauſe the Month hath but 30 days in it, and the remain is 22, the *Age* of the *Moon* that day. Had it been the 22th. of *Auguſt*, and added them together, it would have made 51. Then to have taken 30 out, there had remained 21 for the ☽*Moon's Age* the 22 day of *Auguſt*.

V. *To finde what* Sign *the* Moon *is in, by which is gathered, what the* Moon *differeth from the* Sun.

MUltiply the *Age* of the *Moon* by 4. divide the *Augment* or *Sum* by 10, the *Quotient* ſheweth the *Sign* the *Moon* differeth from the *Sun*; the Remain multiplied by 4, giveth the *Degrees* to be added. As for Example,——The *Moon* 22 days old, I demand what ſhe differeth from the *Sun*? Multiply 22 by 4, and the Product is 88. That divide by 10, and in the Quotient is 8, and 8 remaineth upon the Diviſion: That multiplied by 4, is 32; from which take 30, the number of *Degrees* in a *Sign*, and add the 8 *Signs* in the Quotient, it makes 9 *Signs*. The odd 2, multiplied by 4, make 8 *Degrees*; to which add the *Sun's Motion* from his entrance into the *Sign* ♎ which was the 14 day, to the 21, make 7 days or *Degrees* to be added, to the 8 *Degrees* make 9 *Signs* 15; which counted after this manner, from ♎, ſaying, ♏ 1, ♐ 2, ♑ 3, ♒ 4, ♓ 5, ♈ 6, ♉ 7, ♊ 8, ♋ 9 *Sign*, and the odd 15 *Degrees* is 15 *Degrees* of *Cancer*. So the Queſtion is anſwered, That the ☽*Moon* is 9 *Signs* 15 *Degrees* from the *Sun*, at 22 days old; which note, She differeth but 4 *Degrees* from her true *Motion* by the Tables, which is near enough for the *Mariner* to anſwer any Man.

(8 | 22
88 (8 | 4
☌ | 88

How

How to find what Sign *the* Moon *is in more exact; with the* Moon's Motion *for every day of her* Age.

Astronomers divide the Compaſs of the *Heavens* into 12 *Signs*, which they ſet forth by theſe Names and Characters, which you muſt be a little acquainted with, and the place of the *Sun* in the *Zodiack*. Each of theſe *Signes* you have them as followeth.

First know, That the *Sun* entreth the firſt *Sign* ♈ the 11th of *March*, ♉ the 11th of *April*, ♊ the 12th of *May*, ♋ the 12th of *June*, ♌ the 14th of *July*, ♍ the 14th of *Auguſt*, ♎ the 14th of *September*, ♏ the 14th of *October*, ♐ the 13th of *November*, ♑ the 12th of *December*, ♒ the 11th of *January*, ♓ the 10th of *February*. This known, the place of the *Sun* is well found, adding for every day paſt any of theſe, 1 *Degree*.

Thus you ſee, the *Sun* runs through theſe 12 *Signs* but once in a year; The *Moon* in leſs than a Month, *viz.* in 27 days, 7 hours, 43 minutes. *Note*, That every *New-Moon*, the *Sun* and *Moon* are in one *Sign* and *Degree*; but the *Moon* hath a Motion of about 13 *Degrees* every day, as is ſhewed in this Table. Therefore according to the Age of the *Moon*, add the *Signs* and *Degrees* of the *Moon's Motion*, to the place of the *Sun* at the *New Moon*, and ſo you ſhall have the *Sign* and *Degree* which the *Moon* is in at any time deſired.

Thus for Example, A *New-Moon* 1665. the 26th. *November*, and the *Sun* and *Moon* are both in 14 *Degrees* of ♐. Now upon the 11th of *December*, the ☽ being 14 days old, I would know what *Sign* the *Moon* is in. This *Table* ſhews, for the 14 days of the *Moon's Motion*, you muſt add 6 *S*, 4 *D*, 28 *Min.* to the ſaid 14 *Degrees* of ♐.

Now counting thoſe 6 *Signs* upon your Fingers, reckoning the Names of the *Signs* in order from *Sagittarius*, ♍ 1, ♎ 2, ♏ 3, ♐ 4, ♑ 5, ♒ 6, it falls upon the *Sign Gemini*. Laſtly, adding the odd 14 *Degrees* unto the 4 *Deg.* of the ☽ *Moon's Motion* together, ſhews the place of the *Moon* to be in 18 *Degrees* of *Gemini*.

There is much uſe made of the ☽ *Moon's* being in ſuch and ſuch *Signs*, in *Phyſick* and *Husbandry*, of which I ſhall ſay nothing; but give you one Concluſion which much depends hereon; that is,

A Table ſhewing the Moon's Motion *according to her* Age.

D. Age.	*S.*	*D.*	*M.*
1	00	13	11
2	00	26	21
3	01	09	32
4	01	22	42
5	02	05	53
6	02	19	04
7	03	02	04
8	03	15	26
9	03	28	35
10	04	11	46
11	04	24	56
12	05	08	07
13	05	21	18
14	06	04	28
15	06	17	39
16	07	00	49
17	07	14	00
18	07	27	11
19	08	10	21
20	08	23	32
21	09	06	42
22	09	19	53
23	10	03	03
24	10	16	14
25	10	29	25
26	11	12	35
27	11	25	46
28	12	08	56
29	12	22	07
30	13	05	17

To know the time of the Moon's Riſing, Southing, *and* Setting.

FOr her *Riſing* (know this) having found the place, or what *Sign* ſhe is in, ſeek out in the following *Kalendar* what time the Sun is in this *Sign* and *Degree*, and there you ſhall find the true time of the *Sun-Setting*, being in that place: This is half the continuance of the *Sun* above the *Horizon* in that *Sign* and *Degree*. Add this to the time of the ☽ *Moon's* coming to the *South*, it ſhews the time of her *Setting*; and ſubſtracted from it, ſhews the time of her *Riſing*.

Thus upon the 11th of *September*, as before, the *Moon* being 14 days old, and in the 18 *Degree* of *Gemini*, I deſire to know the time of the *Moon's Riſing* and *Setting*.

First multiply 14, the *Moon's Age*, by 4. Divide the Product by 5. In the Quotient will be 11 a Clock, and the one Unite upon the Diviſion is Mm. 12, that the *Moon* will be *South* that night. Secondly, The *Sun* is in this *Sign* and *Degree* about the firſt day of *June*, and then ſets at 8 a Clock 10 minutes paſt. This ſubſtracted, ſhews the *Riſing* of the *Moon* to be at 3 of the Clock 2 minutes in the afternoon. The ſaid 8 hours, 10 being added, makes 19 hours 22 min. which by caſting away 12, the remain ſhews the *Moon's Setting* to be at 7 of the Clock, and 22 min. paſt in the morning, which anſwers the Queſtion deſired; which is as neer as can be for your uſe.

	H.	M.
☾ *So.*	11	12
☉ *Set.*	8	10
☾ *Riſ.*	3	02
Added	19	22
☾ *Set.*	7	22

PROP. I. *How to find when it is* Full-Sea *in any* Port, Rode, Creek, *or* River.

I have ſhewed you already how to find the *Prime*, *Epact*, and *Age* of the *Moon*, at any time deſired. Now we will proceed to ſhew you the finding of *Full-Sea* in any Place; as in manner following.— *Firſt*, Carefully watch the time of *High-Water*, and what Point of the *Compaſs* the *Moon* is upon, on her *Change-day*, in that *Port* or Place where you would know the time of the *Full-Sea*, or find by the *Table* what *Moon* makes a *Full-Sea* in the ſaid *Port*. *Secondly*, Conſider the *Age* of the *Moon*; then by *Arithmetick* reſolve it in this manner. Multiply the *Moon's Age* by 4, divide the Product by 5, the Quotient ſhews the *Moon's* being *South*. If any thing remaineth upon the Diviſion, for every Unite you muſt add 12 Min. If it was 4 remaining, it would be 48 Minutes to be added. Then add the hour that it Flows on the *Change-day* to it, and the Total is the hour of *Full-Sea*. If it exceed 12, ſubſtract 12 from it, the remain is the hour of the day or night of *Full-Sea*, in any *Port*, *River*, or *Creek*. Which I will make plain by ſome *Examples*, (*viz.*)

PROP. II. *The* Moon 16 *days old, I demand, What a Clock it will be* Full-Sea *at* Briſtol, Start-point, *and* Waterford, *where* E. b. S. Moon *maketh* Full-Sea *on* Change-day?

Conſider here an *E. b. S. Moon* maketh 6 hours 45 min. and the *Age* of the *Moon* is 16 days old: Therefore multiply the *Age* by 4, and it makes 64; divide that by 5, and it is 12, and 4 remaineth, which is 48 min. To it add 6 hours 45 min. *E. b. S.* it makes 19 ho. 33 min. Therefore ſubſtract 12 hours from it; there remaineth 7 a Clock 33 minutes, the time of *Full-Sea* in the morning at the aforeſaid *Ports*; which you may compare with your *Inſtrument*, and find it very well agree.

☾ *Age*	16	
	4	
	64	
	h.	*m.*
64 (12	48	
55		
E. b. S.	6	45
Total	19	33
Subſt.	12	00
F. Sea.	7	33

PROP. III. *The* Moon *being* 25 *days old, I demand, What a Clock it will be* Full-Sea *at* London, Tinmouth, Amſterdam, *and* Rotterdam, *where it flows* S. W?

Conſider that at theſe Places on the *Change-days* a *S. W. Moon* maketh *Full-Sea*, which is 3 hours. Therefore multiply 25, the *Moon's Age*, by 4, it makes 100. That divide by 5, in the Quotient will be 20, and nothing remain. To it add 3 ho. *S. W.* and it makes 23 hours. From it ſubſtract 12, and the Remainder ſhews you, That it will be *Full-Sea* at all the aforeſaid Places, at 11 of the Clock in the morning. So you will find it agree with your Inſtrument.

Age ☾ 25
4
100
♑
100 (20
55 3 *S. W.*
23
12
11 *Full Sea.*

PROP.

PROP. IV. *The* Moon *being 9 days old, I desire to know the hour of* Full-Sea *at* Quinborough, Southam. *and* Portsmouth.

Note, That a *South-Moon* on the *Change-day*, maketh *Full-Sea* at these Places. Therefore multiply the *Moon's Age* by 4, it makes 36. That divide by 5, and the Quotient is 7 of the Clock; and 1 remaineth, which is 12 minutes, the time of *Full-Sea* at the aforesaid Places, the *Moon's Age* being nine days. *Note*, If a *North* or *South Moon* makes *Full-Sea* on the *Change-day*, there is nothing to be added to the Quotient; but the Quotient is the hour of the day, and the Remainder is the min. as before directed. One Example more shall suffice.

9
4
36
5
1 12

PROP. V. *The* Moon 5 *days old, I demand the time of* Full-Sea *at* Rochester, Malden, Blacktail, *where* S. b. W. Moon *is* Full-Sea.

Here you may note, That on the *Change-day* at these Places it flows *S. b. W.* which is but one Point from the *South*, being but $\frac{1}{4}$ of an hour, or 45 min. And it had been all one if it had been *North-by-East*. Multiply by 4, divide by 5, and the Quotient will be 4; to it add 45 min. *S. b. W.* shews you it will be *Full-Sea* at the aforesaid Places at 4 a Clok and 45 min. in the morning. But note, Had it been *S. b. E.* or *N. b. W.* it had been 11 ho. 15 min. By this time I hope I have made the *Practitioner* able to know the time of *Full-Sea* in any *Port*, by *Instrument* and *Arithmetick*: Therefore I will leave him a small *Table* for his use.

A TIDE-TABLE.

	H.	M.
Rye, Winchelsey, Culsset, a S. b. E. Moon.	11	15
Rochester, Malden, Blacktaile, S. b. W.	0	45
Yarmouth, Dover, Harwich, S. S. E.	10	30
Gravesend, Downs, Blackness, Silly, S. S. W.	1	30
Needles, Orford, South and *North Fore-land*, S. E. b. S.	9	45
Dundee, St. Andrews, Lisbone, St. Lucas, S. W. b. S.	2	15
Poole, Isles of *Man, Dunbar, Diepe*, S. E.	9	00
London, Tinmouth, Amsterdam, Rotterdam, S. W.	3	00
Portland, Hartslew, Dublin, S. E. b. E.	8	15
Barwick, Flushing, Hamborough, S. W. b. W.	3	45
Milford, Bridgewater, Lands-end, E. S. E.	7	30
Baltimore, Corke, Severn, Calice, W. S. W.	4	30
Bristol, Start-point, Waterford, E. b. S.	6	45
Falmouth, Humber, Newcastle, W. b. S.	5	15
Plimouth, Hull, Lyn, St. Davids, W. & E.	6	00
Quinborough, Southam. Portsmouth, N. & S.	0	00

Add any two Numbers together of the foregoing *Table*, and they shall be 12 hours; Except the two last, *N.*, *S.* and *E. W.* So that you may perceive, what hath been said from the *South*, either *Eastward* or *Westward*, the same answereth to the *North*, either *Westward* or *Eastward*. And so much for the *Tydes*. But we will know the *Moon's Motion*, and the Proportion between *Tyde* and *Tyde*.

PROP. VI. *The* Motion *of the* Moon, *and the Proportion of Time betwixt* Tyde *and* Tyde.

After all this, I will shew you in brief the *Motion* of the *Moon*, and the reason of the difference between *Tyde* and *Tyde*.

You must note, the *Motion* of the *Moon* is twofold. *First*, A violent *Motion*, which is from *East* to *West*, caused by the diurnal swiftness of the *Primum Mobile*. *Secondly*, A natural *Motion* from *West* to *East*, which is the reason the *Moon* requireth 27 days and 8 hours 8 min. to come into the same minute of the *Zodiack* from whence she

ſhe departed. But coming to the ſame Point and Degree where ſhe was in Conjunction with the *Sun* laſt, ſhe is ſhort of the *Sun*, by reaſon the *Sun's Motion* every day is natural *Eaſt*, 1 Degree, or 60 Minutes, which maketh ſo much difference, that the *Moon* muſt go longer 2 days, 4 ho. 36 min. neareſt, more than her natural *Motion*, before ſhe can fetch up the *Sun*, to come into Conjunction with her: So that betwixt *Change* and *Change* is 29 days, 12 hours, 44 min. by my account. The *Mariners* always allow juſt 30 days between the *Changes*, by reaſon he will not be troubled with ſmall Fractions of Time, in this Account of *Tydes*, which breedeth no great error: *Experience* therefore muſt needs ſhew me this, That I muſt allow the ſame Proportion to the *Moon* in every 24 hours, to depart from the *Sun* 12 Degrees, which is 48 min. of time, untill her full *Eaſt*; but then having performed her *Natural Motion* above half the *Globe*, ſhe is to the *VVeſt*, as we may know by Reaſon. ¶ Now if the *Moon* move in 24 hours, 48 min. then in 12 hours ſhe muſt move 24 min. and in ſix hours, 12 min. By this proportion each hour ſhe moveth 2 min. So the *Tydes* differeth as the time differeth.

I will add one old approved Experience for the *Mariners* uſe, though it is impertinent in this place; that is, to cut Hair, the *Moon* in ♉, ♍, ♎: Cutting, ſhaving, clipping in the *Wane*, cauſeth baldneſs; but the beſt time in the *Wane*, is in ♋, ♏, or ♓. So I hope I have ſatisfied the *Learner* concerning the *Moon*.

THE

THE Mariners Magazine; OR, *STURMY*'s Mathematical and Practical ARTS.

The Practick Part of Navigation, *in working of a* Ship *in all Weathers at* Sea.

WE have been ſhewing the *Practitioner* all this while, the *Courſe* and *Motion* of the *Moon*, and ſo by it to know how to ſhift the *Tydes*, or time of *High-Water*, in any *Port*, *Road*, *Harbour*, or *Creek*, Inſtrumentally and Arithmetically. The next thing to be obſerved by a *Learner*, is the *Words* of *Command*, with readineſs to anſwer and obey, which is the moſt excellent Ornament that can be in a Compleat *Navigator*, or *Mariner*. And as Captains Exerciſe their Men on Shore, that their Souldiers may underſtand the Poſtures of War, and to execute it when the Word of Command is given by their Commander; In like manner are *Seamen* ond *Mariners* brought up in Practical Knowledge of *Navigation* at *Sea*, in working a Ship in all Weathers. Although the Rules here demonſtrated, are but of little benefit to him, that hath been brought up all his Life-time at *Sea*; and leſs to thoſe that be altogether ignorant in *Marine Affairs*: But that the *Practick* may be delivered in proper *Sea-Phraſes*, according to each ſeveral Material that belongs to a *Ship* compleatly rigg'd, with the Uſe of the ſeveral Ropes in working and trimming of Sails at *Sea* on all Occaſions, cannot be denied by thoſe that know theſe things perfectly: Therefore it is impoſſible for any Man to be a Compleat *Mariner* or *Navigator*, without he hath attained to the true Knowledge of *Theorick* and *Practick*, being both *Siſters* and inſeparable *Companions*, that makes them perfect *Navigators*; Therefore I could not let this ſcape my Pen.

And to explain my ſelf, that I may prevent the Cenſures of all ſuch that will be curious, inquiring whether I am not lame, or incapable of that, and like themſelves appear imperfect; I may ſpeak it with trouble to my ſelf, and ſhame to others, That there was never more lame and decrepit Fellows preferred by *Favour* and *Fortune*, as alſo by *Kindred*, and by Serving for Under-Wages (which a deſerving Man might and would have) as is now adays. Let a man go aboard the beſt Ship at Sea, and it will be very rare to find *Ignorance* out of the Officers Cabins, and commonly able *Mariners* and more ſufficient Men before the Maſt, which are firſt to hawl a bowling, through the averſeneſs of their Fates, which is great pity. I ſhould be glad to live to ſee a more equaller *Balance* among *Sea-men*, and their *Imployers*, to further the induſtrious, and encourage the deſerving Men; for if this partiality ſhould continue long, it is to be feared, in ſome ſhort time, the *Compleat Mariner* will be hardly found aboard any Ship, to the great diſparagement of our *Engliſh* Nation, which hath from time to time ſo long deſervingly had the *Superiority* over all other parts of the World, for breeding the moſt famous *Navigators*. The *Hollander* to his Loſs knows it right well, that there are none like *Engliſh* for Courage at *Sea*; but that many of them out-ſtrip us in the Art of *Navigation*, which proceeds from the former

unequal

unequal *Balance*, which makes our expert *Saylers* to ſeek if *Fortune* will be favourable amongſt them, They had not at this day been *High* and *Mighty*, and in ſuch a flouriſhing Condition as now they are. Therefore I hope to ſee and hear, That the *Engliſh Mariner* will make better uſe of ſwift-ſtealing *Time*, that he may redeem what is loſt, and attain to ſuch perfection, as that he may parallel his *Art* with his *Valour* and *Courage*: And that *Imployers* will uſe more Equity in placing deſerving men according to their merit. I ſhall not draw out my Digreſſion to any longer Diſcourſe; for I know my plain *Rhetorick* will not reliſh in ſome mens ears, though it may in others: Therefore I ſhall draw to a Concluſion, deſiring that no man will cenſure me, before he knows what is in me, or is able to mend this. For ſome there are; being a little touched (as the common Saying is) that if they had me at Sea, they would put me to ſeek all my preſcribed Rules; but I would have ſuch to know, That when I at Sea, I ſhall work the Ship in all Aſſays as well as ever they did, and can as often as I ſhall be called thereunto, after this manner, (*viz.*)

PROP. I. *The Wind is fair.*

The Wind is fair, though but little; he comes well, as if he would ſtand; therefore up a hand and looſe fore Top-ſail in the Top, that the Ships may ſee we will Sail; Bring Cable to the Capſton, have up your Anchor, looſe your Fore-ſail in the Brailes; put abroad our Colours, looſe the Miſne in the Brailes. Is all our men on board? Thoſe that be on Shore may have a Towe, and be bleſt with a Rudder, for we will ſtay for no man. Come my Hearts, have up your Anchor, that we may have a good Prize. Come, Who ſay *Amen*? One and all. Oh brave Hearts, the Anchor is a Peck; have out fore Top-ſail, have out main Top-ſail, hawl home the Top-ſail Sheets. *The Anchor is away*, let fall your Fore-ſail, hoiſe up your fore Top-ſail, hoiſe up your main Top-ſail; up and looſe the Main-ſail, and ſet him; looſe Sprit-ſail, and Sprit-ſail Top-ſail. A brave Gale. Bring the fore-Tack to the Cat-head, and trim our Sails quartering; hoiſe up our ſmall Sails; have out the Miſne Top-ſail and ſet him. Now we are clear, and the Wind like to ſtand; hoiſe in our Boats before it is too much Sea; aboard Main-tack, aboard Fore-tack, a Lee the Helmne handſomly, and bring her to eaſily, that ſhe may not ſtay. Breace the Fore-ſail and Fore-top-ſail to the Maſt, and hawl up the Lee-Bowlings, that the Ship may not ſtay; paſs Ropes for the Boot on the Lee-ſide, and be ready to clap on your Tackle, and hoiſe them in; ſtow them faſt. Let go the Lee-Bowling of Fore-ſail, and Weather-Braces. Right your Helmne, hale aft the Fore-ſheet, trim the Sails quartering as before: Let go the Sprit-ſail Breales, and haſt of the Sheets; and hoiſe up the Sprit-ſail Top-ſail, and other ſmall Sails. Set the main Stay-ſail, and fore Top-ſail, Stay-ſail and Miſne Stay-ſail, and main Top-ſail, Stay-ſail and leeſe in your Boonets, that we may make moſt of our way. To our Station, and clear your Ropes. Come, get up our ſteering Sails. The Lee ſteering Sails of Main-ſail, and Main-top-ſail, Fore-ſail and Fore-top-ſail only; for they will ſet faireſt, and draw moſt away. I have on purpoſe omitted ſeveral Words, by reaſon I would not trouble the *Reader* with ſuch indifferent things as is conceived by all *Mariners* to be done; as Cooning the Ship, Breaſing, Vereing, and haleing aft, and hoiſing, looring, and the like: but it is to be ſuppoſed all to be done at the ſame time. Thus have you a brave Ship under all her Sails and Canvas, in her ſwifteſt way of Sailing upon the Sea. Now let us have her right before the Wind.

Right afore the Wind, and a freſh Gale.

The Wind is vered right aft; take in your Fore and Fore-top-ſail, Steering-ſail, and Fore-top-ſail, and Main and Main-top-ſail, Stay-ſails; for they are becalmed by the after Sails, and will only beat or rub out. The Wind blows a freſh Gale, round aft the Main-ſheets, and Fore-ſheets, bruſſe. Squared your Yards, take in your Main and Main-top-ſail, Steering-ſails. Unleaſe your Bonnets. Take in your Main and Fore-top-gallant-ſails, In the Sprit-ſail, and Miſne Top-ſail, let go the Sheets, hale from

the

the Cholyens, caſt off Top-gallant Bowlings. Thus you have all the ſmall Sails in, and furled, when it blows too hard a Wind to bear them.

The Wind vereth forward, and ſcanteth.

The Wind ſcanteth, vere out ſome of your Fore and Main-ſheets, and Spriſle-ſheets, and let go your Weather Braces; tope your Sprit-ſail Yard. The Wind ſtill vereth forward; Get aboard the Fore and Main-Tack; caſt off your Weather-ſheets and Braces: The Sails are in the Wind, hawle off Main and Fore-ſheets; the Wind is ſharp, hawl forward the main Bowline, and hawl up the Main top-ſail, and Fore top-ſail Bowline, and ſet in your Lee-braces, and keep her as near as ſhe will lie. Thus have you all the Sails trimm'd ſharp, full, and by a Wind.

The Wind blows Friſking.

The Wind blows hard; ſettle our fore and main Top-ſails two thirds of the Maſt down. It is more Wind, come, hawl down both Top-ſails cloſe. Come, ſtand by, take in our Top-ſails; Let go the Top-ſail Bowlines, and Lee-Braces; let go the Lee-Sheets, ſet in your Weather Braces, ſpill the Sails, hawl home the Top-ſail Clue-lines, ſquare the Yeard. Now the Sail is furled, and you have the Ship in all her low Sails, or Courſes at ſuch a time.

It bloweth a Storm.

It is like to over-blow; Take in your Sprit-ſail, ſtand by to hand the Fore-ſail. Caſt off the Top-ſail Sheets, Clue-garnets, Leech-lines, Bunt-lines; ſtand by the Sheet, and brace; loure the Yeard, and furl the Sail (here is like to be very much Wind) See that your main Hallyards be clear, and all the reſt of your Geer clear and caſt off. (It is all clear.) Loure the main Yard. All down upon your doone hall; now the Yard is down, hawl up the Clue-garnets, Lifts, Leach-lines, and Bunt-lines, and furle the Sail faſt, and faſten the Yards, that they may not travers and gall. Thus have you the Ship a trije under a Mizen.

A very hollow grown Sea.

We make foul weather, look the Guns be all faſt, come hand the Mizen. The Ship lies very broad off; it is better ſpooning before the Sea, than trying or hulling; go reefe the Fore-ſail, and ſet him; hawl aft the Fore-ſheet; The Helmne is hard a weather, mind at Helmne what is ſaid to you carefully. The Ship wears bravely ſtudy, ſhe is before it, and the Sheets are alle and braces; belay the fore doon hall, that the Yard may not turn up; it is done. The Sail is ſplit; go hawl down the Yeard, and get the Sail into the Ship, and unbind all things clear of it, and bring too the Fore-bonnet; make all clear, and hoiſe up the Fore-yard; hawl aft the Sheets, get aft on the Quarter-Deck, therefore Braces.

Starboard; hard up, right your Helmne Port. Port hard, more hands, he cannot put up the Helmne. *A very fierce Storm.* The Sea breaks ſtrange and dangerous; ſtand by to hawl off above the Lennerd of the Whipſtaff, and help the man at Helmne, and mind what is ſaid to you. Shall we get down our Top-maſts? No, let all ſtand; yet we may have occaſion to ſpoon before the Sea with our Powles. As we maſt, get down the Fore-yeard— She ſcuds before the Sea very well; the Top-maſt being aloft the Ship is the holſomeſt, and maketh better way through the Sea, ſeeing we have Sea-Room. I would adviſe none in our condition to ſtrike their Top-maſts, before the Sea or under. Thus you ſee the Ship handled in fair weather and foul, by and learge. Now let us ſee how we can turn to windward.

The Storm is over, let us turn to Windward.

The Storm is over, ſet Fore-ſail and Main ſail; bring our Ship too; ſet the Miſne, and Main Top-ſail, and Fore Top-ſail. Our Courſe is *E. S. E.* the Wind is at *South*: Get the Starboard-Tacks aboard, caſt off our Weather Braces and Lifts; Set in the Lee-Braces, and hawl forward by the Weather Bowlines, and hawl them taught and belaye them, and hawl over the Mizen Tack to Winerd; keep her full, and by as near as ſhe will lye. *How Wind you? Eaſt.* A bad quade Wind. (No near) hard, no near. The Wind vereth to the *Eaſtward* ſtill. *How Wind you? N. E.* hard, no near. The Wind is right in our teeth; no near ſtill. *How wind you? N. W. b. N.* The Wind will be *Northerly*, make ready to go about; we ſhall lay our Courſe another way, no near, give the Ship way, that ſhe may ſtay: ready, ready a Lee the Helmne. Vare out there Fore-ſheet, caſt off your Lee-Braces, brace in upon your Weather Braces. The Fore-ſails is a back ſtays, hawl Main-ſail, hawl, about, let riſe the main Tack, caſt off your Larboard-Braces, let go main Bowline, and main Top-ſail Bowline; brace about the Yard, hawl forward by the Larboard-Bowlines; get the main Tack cloſe down, in the Cheeſe-tree: hawl up the Weather Bowline, and ſet the Lee Brace of Main and Main Top-ſail Yards, and the Sheets is cloſe aft; hawl, of all; hawl; get to fore-Tack, let go fore-Bowline, and fore-Top-ſail Bowline; hawl aſſe the fore-Sheet, hawl taught, the main Bowline, and main Top-ſail Bowline; ſhift the Mizen, tack, hawl bout fore Bowline, and fore Top-ſail Bowline; ſet in the Lee-Braces taught, fore and aft, keep her as near as ſhe will lie.—— No near, *How Wind you? N. N. E.* thus werr no more; no near, keep her full. The Wind is at *N. N. E.* thus werr no more. (*How Wind you?*) *E. N. E.* The Wind is at *N.* keep her away her Courſe *E. S. E.* Caſt off the Lee-Braces, and Weather-Bowlines, and ſet in your Weather-Braces. Vere out the main Sheet, and fore Sheet, looſe the Sprit-ſail, and Spit-ſail, Top-ſail, and Mizen Top-ſail, and Top-gallant-ſails; hoiſe them up, the Wind vears aſſe ſtill; let riſe the fore-Tack: the Wind's quartering, hawl aft the fore-Sheet, bring him down to the Cat-head with a paſs-a-ree; ſtuddy in your Weather Braces; the Wind ſtands, here. Thus you have the Ship as at firſt, ſteering under all her Canvas, quarter Wind, as ſhe did at firſt, ſetting Sail. She hath been wrought with all manner of Weather, and all ſorts of Winds. Therefore we will draw to the laſt with a Man of War in Chaſe and taking of her Prize, and ſo leave this Practick Part to your Cenſure.

The Man of War in her Station.

Now we are in our Station, and a good *Latitude*, hand your Top-ſails, and furle your Main-ſail and Fore-ſail, and brail up the Mizen, and let her lie at Hull, until Fortune appear within our *Horizon*. Up alaft to the Top-maſt-head, and look abroad, young-men; look well to the *Weſtward*, if you can ſee any Ships that have been nipt with the laſt *Eaſterly* Winds. *A Sail, a Sail.* Where? Fair by us. How ſtands ſhe? To the *Eaſtward*, and is two Points upon her Weather Bow, and hath her Larboard-Tacks aboard. O then ſhe lies cloſe by a wind; we ſee her upon the Decks plainly. A good man to Helmne. Up young-men, and looſe the Fore-ſail, Main-ſail, and Mizen. Get the Larboard-Tacks aboard; have out the Main top-ſail, and Fore-top-ſail, and looſe the Sprit-ſail, aloofe. Keep her as neer as ſhe will lie; hawl aft the Sheets, and hawl up your Bowlines laught. Do you ſee your Chaſe? *How Wind you? E. N. E.* Then the Wind is at *N.* Hoiſe up your Top-ſails as high as you can; have out Sprit-ſail, Top-ſail, and Mizen Top-ſail; hawl home the Sheets, and hoiſe them up: A young-man and looſe the Main-top-gallant-ſail, and Fore-top-gallant-ſail; hawl home the Sheets, and hoiſe them up; hoiſe up Main Stay-ſail, and Mizen Stay-ſail, and looſe the Main-top-ſail, and Fore-top-ſail; Stay-ſail, and ſet them. It blows a brave chaſeing Gale of Wind; The Ship makes brave way through the Sea; we riſe her apace; if ſhe keep her Courſe, we ſhall be up with her in three Glaſſes. No near, keep the Chaſe open with little of the Fore-ſail. So, thus, keep her thus. Come oſſe all hands, the Ship will Stear the better when you ſit all quiet;

quiet; by, by her ſmall Sails, for ſhe is too much by the Head. The Chaſe is a luſty brave Ship. So much the better, ſhe hath the more Goods in her Hold. The Ship hath a great many Guns (no force) it may be ſhe is a Private *Port*, the Chaſe is about, come fetch her wack, and we will be about after her. We ſayl far better than ſhe; we have her Wack; a Lee the Helmn, about Ship, vere out Fore-ſheet. Every man ſtand handſomly to his buſineſs, and mind the Bowlines and Braces, Tacks and Sheets; hawl Main-ſail, hawl about. Let go Main Bowline, Top Bowline, Top-gallant Bowline; Hawl off all, hawl Fore-ſail, about, ſhifts the Helmn; bring her too, Hawl the Main-ſheets cloſe aſle, and fore-ſheet. Set in the Lee-Braces, hawl too the Bowlines. Thus the Chaſe keeps cloſe to the Wind; keep her open under our Lee. *Gunner*, ſee that you have all things in readineſs, and that the Guns be clear; and that nothing peſter our decks.——Down with all Hammocks and Cabins that may hinder and hurt us. *Gunner*, is all our Geer ready? Is the ſtore of Cartrages ready fill'd, all manner of Shot at the Main-maſt? Is there Rammers, Sponges, Ladles, Priming-Irons, and Horns, Lyntſtocks, Wads, and Water at their ſeveral quarters ſufficient for them? Be ſure that none of our Guns be cloy'd; and when we are in Fight, be ſure to load our Guns with Croſs-bar and Langrel. Always obſerve to give Fire when the Word is given. See that there be Half-Pikes and Javelings in a readineſs, and all our Small-ſhot well furniſhed, and all their Bandaliers fill'd with Powder, and Shot in their Pooches.

See that our Murtherers and Stockfowlers have their Chambers fill'd with good Powder, and Bags of ſmall Shot to load them, that if we ſhould be laid aboard, we might clear our Decks.——Starboard, the Chaſe pays away more room, Starboard hard; Vere our ſome of the Main-ſheet and Fore-ſheet; Caſt of the Larboard-Braces, (Steady) Keep her thus: Well Steer'd; the Chaſe goes away room, her Sheets are both aft, ſhe is right before the Wind: Stereboard hard; Let riſe main Tack, let riſe fore-Tack; Hawl aſle Main-ſheet, hawl aſle fore-Sheet. We have a ſtearn-Chaſe, but we ſhall be up with her preſently, for we fetch upon her hand-going. The Chaſe hawls up his Main-ſail and furles it; ſhe puts aboard her Waſte-clothes; ſhe will fight us. Come up from alow young men, and furle our Main-ſail; ſling our Main Yard, with the Chains in the Main-top; ſling our Fore-yard, put aboard our Waſte-Cloaths; he will fight us before the Winde I ſee; She is full of Men; It is a hot Ship, but deep and foul. Come chearly my Hearts, It is a Prize worth fighting for; The Chaſe takes in her ſmall Sails; Up aloft and take in our Top-gallant-ſails, Sprit-ſails, Top-ſails, Mizen Top ſail, and furle the Sprit-ſail, and get the Yard alongſt under the Bowſprit. She puts abroad her Colours, It is Red, White, and Blew; they are *Dutch* Colours; no force, the worſt of Enemies. Boy, up and put abroad St. *George's* Colours in our Main-top; ſtep oft a hand, and put abroad our bloody Ancient; Call all hands aloft; Come up aloft all hands. They are all up Captain.

Gentlemen, *We are here employed and maintained by his Majeſty King* CHARLES *and our Country, to do our Endeavours to keep this Coaſt from* Pyracy *and* Robbers, *and his Majeſties Enemies; whereof it is our Fortune to meet this Ship at this time: Therefore I deſire you in his Majeſties Name, and for the Sake of our Country, and the Honour of our* Engliſh *Nation, and our ſelves, for every man to behave himſelf courageous like* Engliſhmen; *and not to have the leaſt ſhew of a Coward: but to obſerve the Words of Command, and do his utmoſt endeavour againſt this barbarous and inhumane Enemy the* Dutch, *who have treacherouſly and inhumanely murthered ſo many of our* Engliſh *Nation, in the* Eaſt-Indies *and other Parts, whoſe Blood cries for vengeance. Therefore our Quarrel is juſt, and into Gods hands we commit our Cauſe, and our ſelves. So every man to his Quarters, and ſhew his Courage, and God be with you.*

She ſettles her Top-ſails, we are within ſhot; let all our Guns be looſe, In the Tackles and the Ports, all knockt open, that we may be ready to run out our Guns when the Word is given. Up noiſe of Trumpets, and hail our Prize; ſhe anſwereth again with her Trumpet: Hold faſt Gunner, do not fire till we hail them with our Voices. (*Haye, Hooe*) *Amain for King CHARLES.* (*Port*) edge towards him, he fires his Broad-ſide upon us. (What chear my Hearts?) Is all well betwixt

Decks? *Yea, Yea,* only he rackt us through and through. No force, it is his turn next; but give not Fire until we are within Piſtol-ſhot. *Port,* edge towards him. He plies his ſmall Shot; hold faſt Gunner. *Port,* right your Helmne. We will run up his Side. Starboard a little; Give fire, Gunner. (That was well done.) This Broad-ſide hath made their Deck thin, but the ſmall Shot at firſt did gaul us. Clap in ſome Caſe-ſhot in the Guns you are now a loading; Brace too the Fore-top-ſail, that we may not ſhoot a head; He lies broad off to the Southward, to bring his other Broad-ſide to bear upon us. (Starboard hard.) Get to Larboard Fore-tack; trim your Top-ſails, run out your Larboard Guns. He fires his Sterboard Broad-ſide upon us; He pours in his ſmall Shot. Starboard give not fire until he fall off, that the Prize may receive our full Broad-ſide. Steady: Port a little; give fire Gunner: His Fore-maſt is by the board. This laſt Broad-ſide hath done great Execution. Cheerly my Mates, the day will be ours; He is ſhot a Head; He bears up before the Wind to ſtop his Leaks: Keep her thus; Well Steered. *Port, Port hard*; Bear up before the Wind, that we may give him our Starboard Broad-ſide. Gunner, Is there great ſtore of Caſe-ſhot and Langrel in our Guns? *Yea, yea. Port,* make ready to board him; Have your Laſhers clear, and able men with them. Edge towards him Guns when you give fire; Bring your Guns to bear amongſt his Men with the Caſe-ſhot. Well ſteered, we are cloſe on boord. Give fire Starboard; Well done Gunner; They lie Heads and Points aboard the Chaſe. Come, Aboard him bravely; *Enter, Enter.* Are you laſhed faſt? *Yea, Yea,* We will have him before we go here-hence. Cut up the Decks; Ply your Hand-Granadoes and Stink-Pots. He cries out Quarter; Quarter for our Lives, and we will yield up Ship and Goods. Good Quarter is granted, Provided you will lay down all your Arms, open the Hatches, hawl down all your Sails and furle them; looſe the Lachings, we will ſheer off our Ship, and hoiſe out our Shallop. If you offer to make any Sail, expect no Quarter for your Lives. Go with the Shallop, and ſend aboard the Captain, Lieutenant, and Maſter and Mates, with as many more as the Shallop will carry. So we will leave the *Man of War* to put his Priſoners down into the Hold, and ſecure. And ſo likewiſe I have ſhewn you thus much of the Practick part of *Navigation*, in which you may perceive that I have wrought the Ship in all Eſſays, in Words and proper Sea-Phraſes; and if I was at Sea, I ſhould perform it both in Word and Deed: therefore I leave it all to your Judicious Cenſures. And let not *Ignorance*, the Arch-enemy of *Arts* deceive you, and cauſe you to think that I have writ what I cannot do; but that I can as eaſily turn him in the *Theorick*, which way I liſt, as I can the Ship in the *Practick*. And ſo I will conclude with *Ovid*, when he ſailed in the Straight *Ionian*,

Nothing but Waves we view in Sea where Ships do float,
And Dangers lie, huge Whales, and all Fiſh play:
Above our Heads, Heaven's Star-embroidered Coat,
Whoſe Vault contains two Eyes, for Night and Day;
Far from the Main, or any Marine Coaſt,
'Twixt Borean *Blaſts, and Billows, we are toſt.*

If Ovid *in that ſtraight* Ionian *Deep*
Was toſt ſo hard, much more are we on Seas
Of larger Bounds, where Staff *and* Compaſs *keep*
Their ſtrict obſervance: Yet in this uneaſe
Of Tackling Boards, we ſo the way make ſhort,
That ſtill our Courſe draws nearer to our Port.

Between the Stream and ſilver-ſpangled Skie
We rolling climbe, then hurling fall beneath;
Our way is Serpent-like, in Meads which lie,
That bows the Graſs, but never makes a Path:
But fitter, like young Maids and Youths together,
Run here and there, all where, and none know whether.

Our

Our way we know, and yet unknown to other;
And whiles misknown to us, before we dive:
The Hand and Compaſs *that governs the* Ruther
Do often erre, although the Pilots *ſtrive*
With Card *and* Compaſs, *yet our Reck'nings fall*
Too narrow, ſhort, too high, too wide, too ſmall.

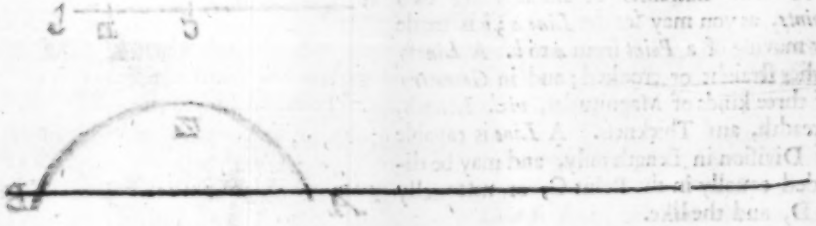
To diſcon this, remark when we ſet Land,
Some this, ſome that do gueſs, this Hill, that Cape.
For ſome howers our Skill in ſuſpence ſtand,
Terming this Shore, that Head-land Points the Map;
Which when miſtook, this forg'd Excuſe goes clear,
O ſuch and ſuch a Land it firſt did 'pear.

In all which ſtrife, ſtreſi'd Sailers *have the pain,*
By drudging, pulling, hawling, ſtanding to it
In Cold and Rain, both dry and wet, they ſtrain
Themſelves, and toyl; none elſe but they muſt do it.
Both Prow *and* Poop *do anſwer to the* Helm;
The Stearſman *ſings, no Grief his Joy can whelm.*

By Night our Watch we ſet, by day our Sight,
And furle our Sails: If Pirates *do appear,*
We reſt reſolv'd; 'Tis Force makes Cowards fight,
Though none more dare, than they that have moſt fear.
It's Courage *makes us raſh, and* Wiſdom *cold;*
Yet Wiſemen ſtout, and ſtung, grow Lion-bold.

Sapientiam Sapiens dirigit, Artes Coartifex, &c. *Phocilides.*

The Wiſe-man knows his Wiſdom *how to uſe,*
Th' Artificer, what Art *'tis beſt to chuſe.*
'Tis a true Saying, and approved long,
The Wiſe-man is more worthy than the Strong.
The Fields *he tills, the* City *he can guide,*
And for the Ships *in* Tempeſts *well provide.*



THE

THE GEOMETRICAL DEFINITIONS.

THE *ARTS*, ſaith *Arnobius*, are not together with our *Minds* ſent out of the Heavenly Places; but all are found out on Earth, and are in proceſs of time ſought and fairly forged by a continual Meditation. Our poor and needy Lives perceiving ſome caſual Things to happen prepoſterouſly, while it doth imitate, attempt, and try, while it doth ſlip, reform, and change, hath out of theſe, ſome Fiduous Apprehenſion made by ſmall *Sciences* of *Art*, the which afterwards by Study are brought to ſome perfection.

Yet the *Practice* of *Art* is not manifeſt but by *Speculative Illuſtration*; becauſe by *Speculation* we know that we may the better know. And for this cauſe I choſe a *Speculative* Part; And firſt of *Geometry*, that you may the better know the Practice.—To begin then.

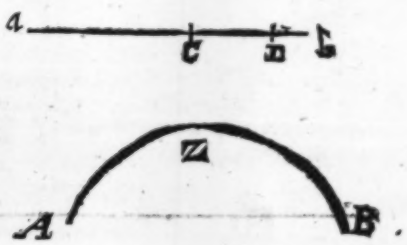
I. *A* Point *is that which hath no Parts.*

A *Point* is ſuppoſed to be a Thing *indiviſible*, or that cannot be divided into parts; yet it is the firſt of all Dimenſions. It is the *Philoſopher's Atome*. Such a Nothing, as that it is the very *Energie* of All Things. In *God* it carrieth its Extremes from Eternity to Eternity; which proceeds from the leaſt imaginable thing, as the Point or Prick noted with the Letter A; and is but only the Terms or Ends of Quantity.



II. *A* Line *is a ſuppoſed Length, without Breadth or Thickneſs.*

A *Lines* Extremes or Bounds are two *Points*, as you may ſee the *Line a*; *b* is made by moving of a *Point* from *a* to *b*. A *Line* is either ſtraight or crooked; and in *Geometry* of three kinds of Magnitudes, *viz.* Length, Breadth, and Thickneſs. A *Line* is capable of Diviſion in Length only, and may be divided equally in the Point C, or unequally in D, and the like.

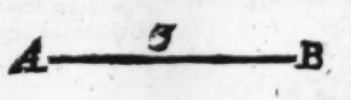


III. *The Ends or Bounds of a* Line *are* Points.

You are to underſtand, the Ends or Bounds of a finite Line is A, B, as before: but in a Circular *Line* it is otherwiſe; for there the *Point* in its Motion returneth again to the Place where it firſt began, and ſo maketh the *Line* infinite.

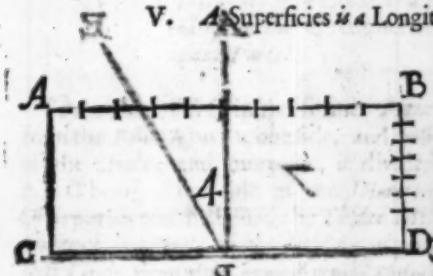
IV. *A* Right Line *is the ſhorteſt of all* Lines, *drawn from any two of the ſaid* Points,

As you may ſee the *Right Line* A B ſtraight, and equal between the Points A and B, without bowing, which are the Bounds thereof.



V. *A*

V. *A* Superficies *is a* Longitude, *having only* Latitude.



Superficies is That which hath only length and breadth, whose Terms and Limits are two *Lines*. In the first kind of Magnitude the Motion of a *Point* produceth a *Line*: So in the second kind of Magnitude, the Motion of a *Line* produceth a *Superficies*. This is also capable of two dimensions, as the length A B and C D, and the breadth A C and B D; and may be divided into any kind or number of Parts,

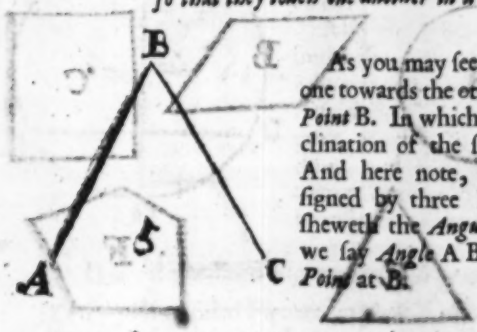
VI. *The Extremes of a* Superficies *are* Lines.

As the Ends of a *Line* are *Points*, so the Bounds or Extremes of a *Superficies* are *Lines*; as before, you may see the Ends of the *Lines* A B, and B D, and D C, and C A.

VII. *A* Plain Superficies *lieth equally between his* Lines.

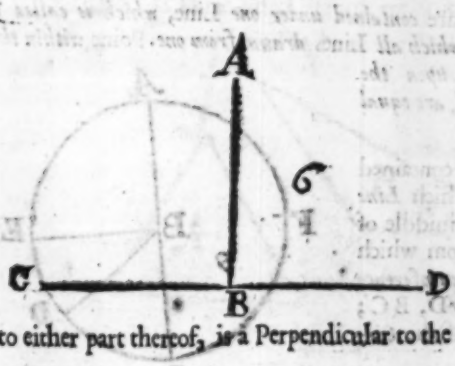
So the *Superficies* A B C D is that which lieth direct and equally between his *Lines*. And whatsoever is said of a *Right Line*, the same is meant of a *Plain Superficies*.

VIII. *An* Angle *is when two* Lines *are extended upon the same* Superficies, *so so that they touch one another in a* Point, *but not directly.*



As you may see the two *Lines* A B and B C incline one towards the other, and touch one the other, in the *Point* B. In which *Point*, by reason of the bowing inclination of the said *Lines*, is made the *Angle* A B C. And here note, That an *Angle* is most commonly signed by three Letters, the middlemost whereof sheweth the *Angular Point*, as in this Figure, when we say *Angle* A B C, you are to understand the very *Point* at B.

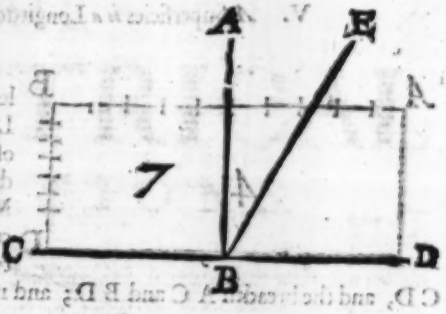
IX. *A* Right Angle *is that which is produced of a* Right Line, *falling upon a* Right Line, *and making two equal* Angles *on each side the* Point *where they touch each other.*



As upon the *Right Line* C D suppose there doth stand another *Right Line* A B, in such sort that it maketh the *Angles* on either side thereof; namely, the *Angle* A B D on the one side equal to the *Angle* A B C on the other side; then are either of the two *Angles Right Angles*; and the *Right Line* A B, which standeth erected upon the *Right Line* C D, without bowing or inclining to either part thereof, is a Perpendicular to the *Line* C D.

X. *An*

X. *An* Obtuse Angle *is that which is greater than a* Right Angle.



So the *Angle* C B E is an *Obtuse Angle*, becauſe it is greater than the *Angle* A B C, which is a *Right Angle*; For it doth not only contain that *Right Angle*, but the *Angle* A B E alſo, and therefore is *Obtuſe*.

XI. *An* Acute Angle *is leſs than a* Right Angle.

Therefore you may ſee the *Angle* E B D is an *Acute Angle*; for it is leſs than the *Right Angle* A B D, in which it is contained by the other *Acute Angle* A B E.

XII. *A* Limit or Term *is the End of every Thing.*

As a *Point* is the *Limit* or *Term* of a *Line*, becauſe it is the End thereof; ſo a *Line* likewiſe is the *Limit* and *Term* of a *Superficies*, and a *Superficies* is the *Limit* and *Term* of a *Body*.

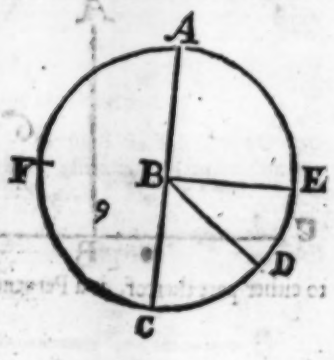
XIII. *A* Figure *is that which is contained under one* Limit *or* Term, *or many.*

As the *Figure* A is contained under one *Limit* or *Term*, which is the round *Line*; alſo the *Figures* B and C are contained under four *Right Lines*: likewiſe the *Figure* E is contained under three *Right Lines*, which are the *Limits* or *Terms* thereof; and the *Figure* F under five *Right Lines*: And ſo of all other *Figures*.



And here note, We call any plain *Superficies*, whoſe Sides are unequal (as the *Figure* F) a *Plot*, as of a Field, Wood, Park, Foreſt, and the like.

XIV. *A* Circle *is a plain* Figure *contained under one* Line, *which is called a* Circumference; *unto which all* Lines *drawn from one* Point *within the* Figure, *and falling upon the* Circumference *thereof, are equal one to the other.*



As the *Figure* A E C F is a *Circle* contained under the *Crooked Line* A E C D, which *Line* is called the *Circumference*. In the middle of this *Figure* is the *Center* or *Point* B, from which *Point* all *Lines* drawn from the *Circumference* are equal, as the *Lines* B A, B E, B D, B C; and this *Point* B is called the *Center* of the *Circle*.

XV. *A*

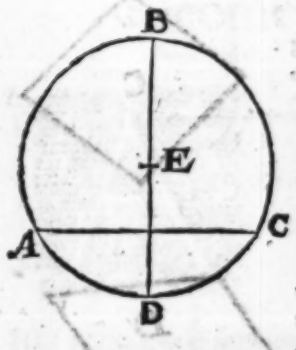
XV. *A* Diameter *of a* Circle *is a* Right Line *drawn by the* Center *thereof, and ending at the* Circumference, *on either ſide dividing the* Circle *into two equal Parts.*

So the *Line* A B C in the former *Figure*, is the *Diameter* thereof, becauſe it paſſeth from the *Point* A on the one ſide, and paſſeth alſo by the *Point* B, which is the *Center* of the *Circle*; and moreover, it divideth the *Circle* into two equal parts, namely, A E C being on one ſide of the *Diameter*, equal to A F C on the other. And this *Obſervation* was firſt made by *Thales Mileſius*; For, ſaith he, if a *Line* drawn by the *Center* of any *Circle* do not divide it equally, all the *Lines* drawn from the *Center* of that *Circle*, from the *Circumference*, cannot be equal.

XVI. *A* Semicircle *is a* Figure *contained under the* Diameter, *and that part of the* Circumference *cut off by the* Diameter.

As in the former *Circle*, the *Figure* A F C is a *Semicircle*, becauſe it is contained of the *Right Line* A B C which is the *Diameter*, and of the *crooked Line* A F C, being that part of the *Circumference* which is cut off by the *Diameter*: Alſo the part A E C is a *Semicircle*.

XVII. *A* Section *or* Portion *of a* Circle, *is a* Figure *contained under a* Right Line, *and a part of the* Circumference, *greater or leſs than a* Semicircle.



So the *Figure* A B C, which conſiſteth of the part of the *Circumference* A B C, and the *Right Line* A C, is a *Section* or *Portion* of a *Circle*, greater than a *Semicircle*.

Alſo the other *Figure* A C D, which is contained under the *Right Line* A C, and the parts of the *Circumference* A D C, is a *Section* of a *Circle* leſs than a *Semicircle*. And here note, That by a *Section*, *Segment*, *Portion*, or part of a *Circle*, is meant the ſame thing, and ſignifieth ſuch part as is greater or leſſer than a *Semicircle*: So that a *Semicircle* cannot properly be called a *Section*, *Segment*, or part of a *Circle*.

XVIII. Right-lined Figures *are ſuch as are contained under* Right Lines.

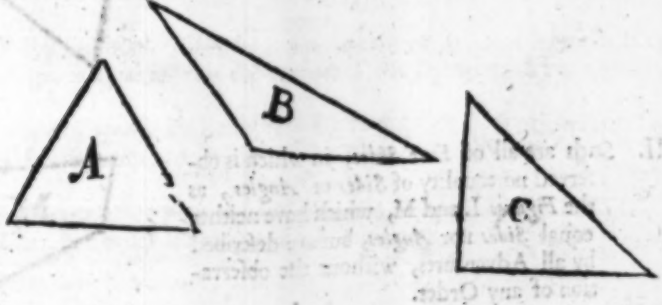
XIX. Three-ſided Figures *are ſuch as are contained under three* Right Lines.

XX. Four-ſided Figures *are ſuch as are contained under four* Right Lines.

XXI. Many-ſided Figures *are ſuch as have more Sides than four.*

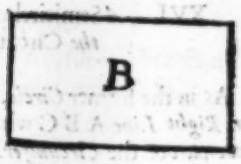
XXII. *All* Three-ſided Figures *are called* Triangles.

And ſuch are the *Triangles* A B C.





XXIII. Of *Four-ſided Figures*, A *Quadrat* or *Square* is that whoſe *Sides* are equal, and his *Angles* right, as the *Figure* A.



XXIV. A *Long Square* is that which hath right *Angles*, but unequal *Sides*, as the *Figure* B.



XXV. A *Rhombus* is a *Figure Quadrangular*, having equal *Sides*, but not equal or right *Angles*, as the *Figure* C.



XXVI. A *Rhomboides* is a *Figure* whoſe oppoſite *Sides* are equal, and whoſe oppoſite *Angles* are alſo equal: but it hath neither equal *Sides*, nor equal *Angles*, as the *Figure* D.



XXVII. All other *Figures* of *Four Sides* are called *Trapezia's*.



XXVIII. Such are all of *Four Sides*, in which is obſerved no equality of *Sides* or *Angles*, as the *Figures* L and M, which have neither equal *Sides* nor *Angles*, but are deſcribed by all Adventures, without the obſervation of any Order.

XXIX. *Parallel*

XXIX. *Parallel* or *Æqui-distant Right Lines*, are ſuch which being in one and the ſame *Superficies* and produced infinitely on both ſides, do never in any part concur; as you may ſee by the two *Lines* A B, C D.

A ——— B
C ——— D



XXX. A *Solid Body* is that which hath Length, and Breadth, and Thickneſs, as a *Cube* or *Die*; and the Limits and Extremes of it are *Superficies*, as the *Figure* I.

XXXI. *Axis* is the *Diameter* about which the *Sphere* or *Globe* is turned.



XXXII. The *Poles* of a *Sphere* are the Extremes or Ends of the *Diameter*, and are terminated in the *Superficies* of the *Sphere*.

XXXIII. A *Sphere* is defined by *Euclid* to be made, when the *Diameter* of a *Semicircle* remaining fixed, the *Semicircle* is turned about, till it be returned to the Place whence it began to move at firſt.

Geometrical Theoremes.

I. ANY two *Right Lines* croſſing one another, make the contrary or vertical *Angles* equal. *Euclid.* 15. 1.

II. If any *Right Lines* fall upon two parallel *Right Lines*, it maketh the outward *Angles* of the one, equal to the inward *Angles* of the other; and the two inward oppoſite *Angles*, on contrary ſides of the falling *Line*, alſo equal. *Euclid* 29. 1.

III. If any Side of a *Triangle* be produced, the outward *Angle* is equal to the inward oppoſite *Angles*, and all the three *Angles* of any *Triangle* are equal to two *Right Angles*. *Euclid* 32. 1.

IV. In Æqui-angled *Triangles* all their Sides are proportioned, as well ſuch as contain the equal *Angles*, as alſo the ſubtendent Sides.

V. If any four *Quantities* be proportional, the firſt multiplied in the fourth, produceth a *Quantity* equal to that which is made by multiplication of the ſecond in the third.

VI. In all Right-angled *Triangles*, the Square of the Side ſubtending the *Right Angle*, is equal to both the Squares of the containing ſides. *Euclid* 47. 1.

VII. All *Parallellograms* are double to the *Triangles* that are deſcribed upon their *Baſis*, their *Altitudes* being equal. *Euclid* 41. 1.

VIII. All *Triangles* that have one and the ſame *Baſe*, and lie between two *Parallel Lines*, are equal one to the other. *Euclid* 37. 1.

Geometrical Problems.

PROBLEM I.

Upon a Right Line *given, how to erect another* Right Line *which ſhall be perpendicular to the* Right Line *given.*
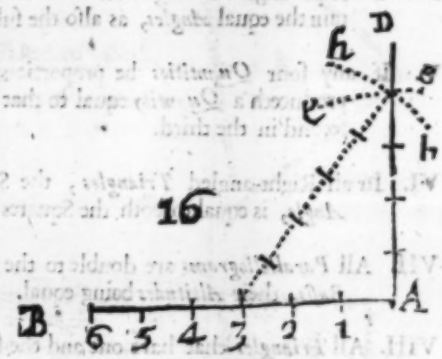
THE *Right Line* given is A B, upon which from the *Point* E it is required to erect the *Perpendicular* E H. Opening your *Compaſſes* at any convenient diſtance, place one Foot in the aſſigned *Point* E, and with the other make the two Marks C and D, equal on each ſide the *Point* E; then opening your *Compaſſes* again to any other convenient diſtance wider than the former, place one Foot in C, and with the other deſcribe the *Arch* G G; alſo (the *Compaſſes* remaining at the ſame diſtance) place one Foot in the *Point* D, and with the other deſcribe the *Arch* F F. Then from the *Point* where thoſe two *Arches* interſect or cut each other (which is at H) draw the *Right Line* H E, which ſhall be *Perpendicular* to the given *Right Line* A B, which was the thing required to be done.



PROBL. II.

How to erect a Perpendicular *on the end of a* Right Line *given.*

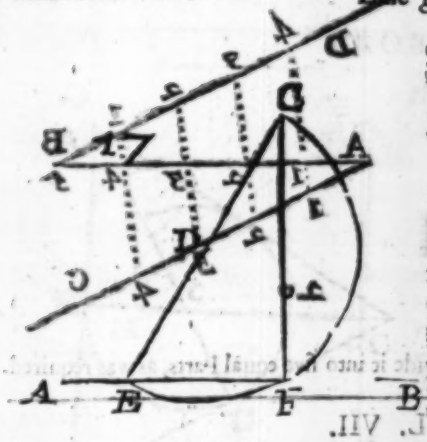
LET A B, be a *Line* given, and let it be required to erect the *Perpendicular* A D. Firſt upon the *Line* A B, with your *Compaſſes* opened to any ſmall diſtance, make five ſmall Diviſions, beginning at A, noted with 1, 2, 3, 4, 5. Then take with your *Compaſſes* the diſtance from A to 4, and place one Foot in A, and with the other deſcribe the *Arch* e e: Then take the diſtance from A to 5, and placing one Foot of the *Compaſſes* in 3, with the other Foot deſcribe the *Arch* h h, cutting the former *Arch* in the *Point* D: Laſtly, from D draw the *Line* D A, which ſhall be *perpendicular* to the given *Line* A B.



This operation is grounded upon this Concluſion, *viz.* Theſe three Numbers 3, 4, and 5, make a Right-angled *Triangle*, which is very neceſſary in many Mechanical Operations, and eaſie to be remembred.

PROBL. III.

How to let fall a Perpendicular ***upon any*** Point ***aſſigned, upon a*** Right Line ***given.***



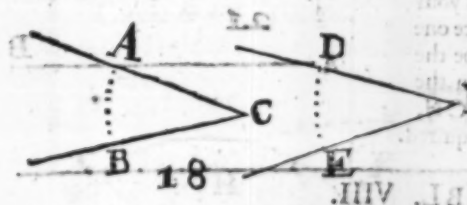
THe *Point* given is C, from which *Point* it is required how to draw a *Right Line* which ſhall be *perpendicular* to the given *Right Line* A B.

Firſt from the given *Point* C, to the *Line* A B, draw a *Line* by chance, as C E, which divide into two equal parts in the *Point* D. Then placing one Foot of the *Compaſſes* in the *Point* D, with that diſtance D C, deſcribe the *Semicircle* C F E, cutting the given *Line* A B in the *Point* F. Laſtly, If from the *Point* C you draw the *Right Line* C F, it ſhall be a *Perpendicular* to the given *Line* A B, which was required.

PROBL. IV.

How to make an Angle ***equal to an*** Angle ***given.***

LEt the *Angle* given be A C B, and let it be required to make another *Angle* equal thereunto.



Firſt draw the *Line* E F at pleaſure; then upon the given *Angle* at C (the *Compaſſes* opened to any diſtance) deſcribe the *Arch* A B; and alſo upon the *Point* F, the *Compaſſes* unaltered, deſcribe the *Arch* D E; Then take the diſtance A B, and ſet the ſame from E to D; Laſtly draw the *Line* D F; So ſhall the *Angle* D F E be equal to the given *Angle* A C B.

PROBL. V.

A Right Line ***being given, how to draw another*** Right Line ***which ſhall be parallel to the former, at any diſtance required.***

THe *Line* given is A B, unto which it is required to draw another *Right Line* parallel thereunto, at the diſtance A C or D B. Firſt open your *Compaſſes* to the diſtance A C or B D; then placing one Foot in A, with the other deſcribe the *Arch* C; alſo (at that diſtance) place one Foot in B, and with the other deſcribe the *Arch* D. Laſtly, draw the *Line* C D, that it may only touch the *Arches* C and D: So ſhall the *Line* C D be parallel to the *Line* A B, and at the diſtance required.

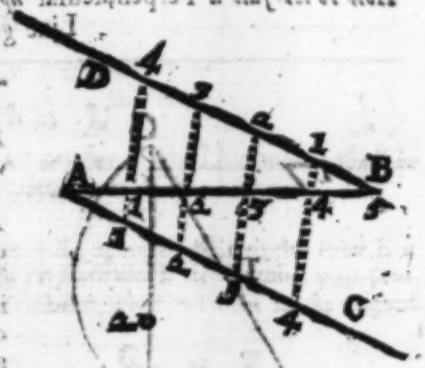


PROBL.

PROBL. VI.

To divide a Right Line *into any number of equal Parts.*

LEt A B be a *Right Line* given, and let it be required to divide the ſame into five equal Parts.

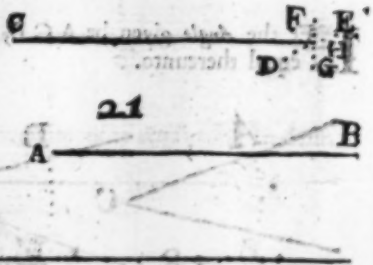


Firſt, From the given Line A, draw the *Line* A C, making any *Angle* from the end of the given *Line* which is at the *Point* B. Then draw the *Line* B D equal to the *Angle* C A B. Then from the *Points* A and B, ſet off upon theſe two *Lines* any Number of equal parts, being leſs by one than the Parts into which the *Line* A B is to be divided, which in this Example muſt be 4. Then draw ſmall *Lines* from 1 to 4, from 2 to 3 twice, and from 1 to 4, *&c.* which *Lines* croſſing the given *Line* A B, ſhall divide it into five equal Parts, as was required.

PROBL. VII.

A Right Line *being given, how to draw another* Right Line *parallel thereunto, which ſhall alſo paſs through a Point aſſigned.*

LEt A B be a *Line* given, and let it be required to draw another *Line* paralle thereunto, which ſhall paſs through the given *Point* C. *Firſt*, Take with your *Compaſſes* the diſtance from A to C, and placeing one Foot thereof at B, with the other deſcribe the *Arch* D E; then take in your *Compaſſes* the whole *Line* A B, and place one Foot in C, and with the other deſcribe the *Arch* F G, croſſing the former *Arch* in the *Point* H: Then if you draw the *Line* C H, it ſhall be parallel to A B, the thing required.



PROBL. VIII.

Having any three Points *given which are not ſcituated in a* Right Line, *How to find the* Center *of a* Circle *which ſhall paſs directly through the three* Points *given.*

THe three *Points* given are A, B, and C; now it is required to finde the *Center* of a *Circle* whoſe *Circumference* ſhall paſs through the three *Points* given.

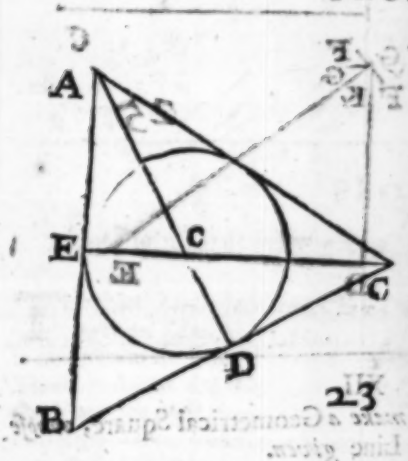


First open your *Compaſſes* to any diſtance greater than half the diſtance between B and C; then place one Foot in the *Point* B, and with the other deſcribe the *Arch* F G; then the *Compaſſes* remaining at the ſame diſtance, place one Foot in the *Point* C, and with the other turn'd about make the marks F and G in the former *Arch*, and draw the *Line* F O G at length, if need be.

In like manner open your *Compaſſes* at a diſtance greater than half A B; Place one Foot in the *Point* A, with the other deſcribe the *Arch* H K: Then the *Compaſſes* remaining at the ſame diſtance, place one Foot in the *Point*

C, and turning the other about, make the marks H K in the former *Arch*. *Laſtly*, draw the *Right Line* H K, cutting the *Line* F G in O, ſo ſhall O be the *Center*, upon which you may deſcribe a *Circle* at the diſtance of O A, and it ſhall paſs directly through the three given *Points* A B C, which was required.

PROBL. IX.

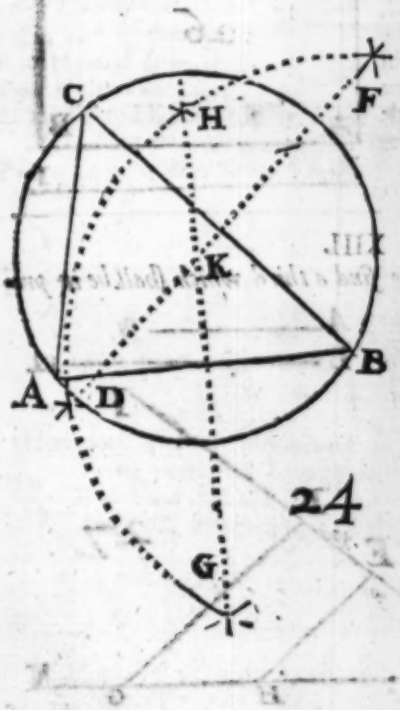


How to deſcribe a Circle *in a* Triangle, *that ſhall only touch the three Sides*; *and to find the* Centre.

LAy down the *Triangle* A B C, the three Sides equal; then divide the Sides of the *Triangle* A B in two equal parts, as at E, and draw the *Line* C E; and likewiſe divide B C, and draw the *Line* A D; and where they croſs one the other, as at O, that is the *Center*: Therefore put one Point of the *Compaſſes* in the *Center* O, and extend the other to either ſide, and deſcribe the *Circle* G F, which will only touch the Sides A B C of the *Triangle*.

PROBL. X.

How to lay down a Triangle *in a* Circle, *and to find the* Center *of the* Circle *in the* Triangle.



DRaw the three Sides of a *Triangle* A B C, it is no matter if they be equal or not; then put one Foot of your *Compaſſes* in the *Point* B, open the other to more than half the length of the greateſt ſide, as to C; and with that diſtance deſcribe the *Arch* F H D G; and ſo removing the *Compaſſes* to C, croſs the former *Arch* at F and D, and draw the *Line* D F. Again, the *Compaſſes* at the ſame diſtance, put one Foot in A, and deſcribing a ſmall *Arch*, croſs the former *Arch* at H and G; and laying a *Ruler* over the Interſections of theſe two *Arches* at H and G, draw the Line G H; and where theſe two *Lines* croſs one the other, as at K, that is the *Center* of the *Triangular Points*. From it extend the *Compaſſes* to either of the *Points*, and deſcribe the *Circle* A B C, and the *Triangle* will be within the *Circle*.

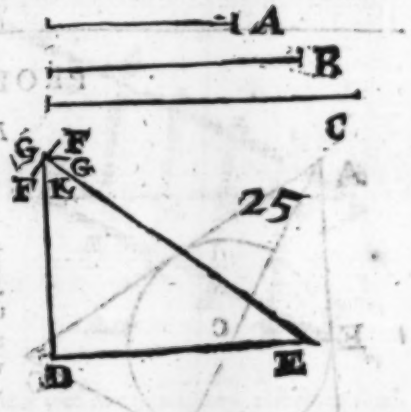
PROBL.

PROBL. XI.

Any three Right Lines ***being given, ſo that the two ſhorteſt together be longer than the third, To make thereof a*** Triangle.

LEt it be required to make a *Triangle* of theſe three *Lines* A, B, and C, the two ſhorteſt whereof, *viz.* A and B together, are longer than the third C.

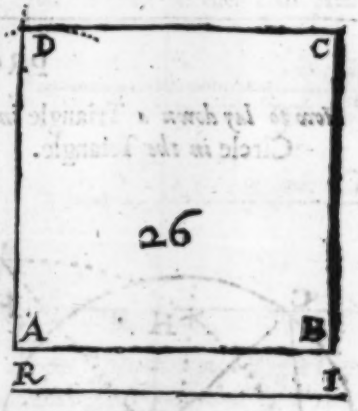
First draw the *Line* D E equal to the given *Line* B; then take with your *Compaſſes* the *Line* C, and ſetting one Foot in E, with the other deſcribe the *Arch* F F: alſo take with your *Compaſſes* the given Line A, and placing one Foot in D, with the other deſcribe the *Arch* G G, cutting the former *Arch* in the *Point* K. *Laſtly*, from the *Point* K, if you draw the *Lines* K E and K D, you ſhall conſtitute the *Triangle* K D E, whoſe *Sides* ſhall be equal to the three given *Sides* A B C.



PROBL. XII.

Having a Right Line ***given, How to make a*** Geometrical Square, ***whoſe*** Sides ***ſhall be equal to the*** Right Line ***given.***

THe *Line* given is R I, and it is required to make a *Geometrical Square* whoſe *Sides* ſhall be equal to the *Line* R I. *Firſt* draw the given *Line* R I, then (by the firſt and ſecond *Problem*) upon the *Point* B raiſe the *Perpendicular* B C, making the *Line* B C equal to the given *Line* R I alſo: Then taking the ſaid R I in your *Compaſſes*, place one Foot in C, with the other deſcribe an *Arch* at D; The *Compaſs* at the ſame diſtance, ſet one Foot in A, and croſs the former *Arch* at D; then draw the Lines D C and D A, which ſhall conclude the *Geometrical Square* A B C D, which was required.

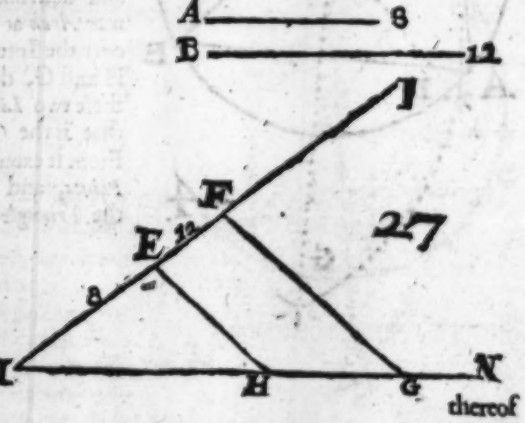


PROBL. XIII.

Two Right Lines ***being given, How to find a third which ſhall be in proportion unto them.***

LEt the given *Lines* be A and B; and it is required to find a third *Line* which ſhall be in proportion unto them.

First draw two *Right Lines*, making any *Angle* at pleaſure, as the *Lines* L M and M N, making the *Angle* L M N: Then take the *Line* A in your *Compaſſes*, and ſet the length thereof from M to E; alſo take the *Line* B, and ſet the Length



thereof

thereof from M to F, and alſo from M to H: Then draw the *Right Line* E H, and then from the *Point* F draw the *Line* F G parallel to E H. So ſhall M G be the third Proportional required: For Arithmetically ſay,

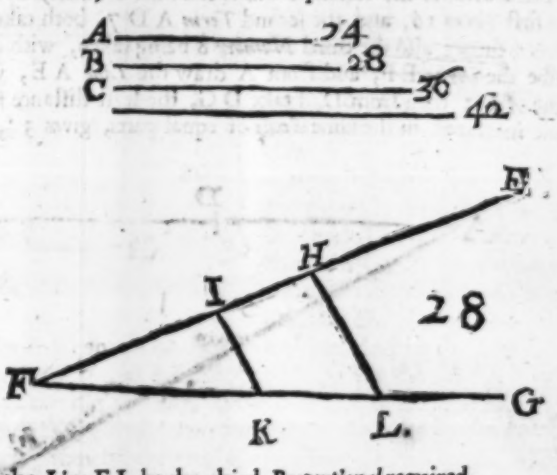
As M E *to* M H: *So is* M F *to* M G 18.

8 12 12 6(0
12 144 (18
24 88
12
144

PROBL. XIV.

Three Right Lines *being given, To find a fourth in proportion to them.*

THe three *Lines* given are A B C, unto which it is required to find a fourth *Proportional Line*. This is to perform the Rule of Three. As in the laſt *Problem*, you muſt draw two *Right Lines*, making any *Angle* at pleaſure, as the *Angle* E F G; then take the *Line* A in your *Compaſs*, and ſet it from F to I; then take the *Line* B in your *Compaſſes*, and ſet that from F to K; then take the third given *Line* in your *Compaſſes*, and ſet that from F to H, and from that *Point* H draw the *Line* H L, parallel to I K; So ſhall the *Line* F L be the third *Proportional* required.



Note, That theſe *Lines* are taken off a *Scale*, that is divided into 20 parts to an Inch: To do it *Arithmetically* ſay,

As F I *is to* F K: *So is* F H *to* F L.

24 28 36 42
28
288
24
1008 (42
144
72
1008
2

Here note, That in performance of the laſt *Problems*, That the firſt and third *Terms*, namely the *Lines* A and C, muſt be ſet upon one and the ſame *Line*, as here upon the *Line* F E, and the ſecond *Line* B muſt be ſet upon the other *Line* F G, upon which *Line* alſo the fourth *Proportion* will be found.

PROBL. XV.

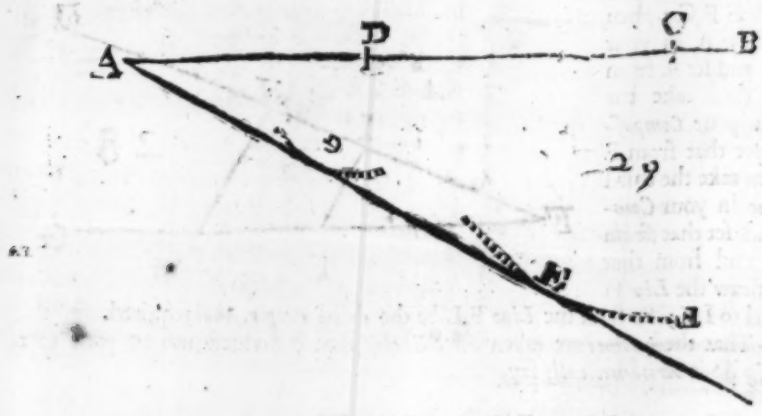
How to work the Rule *of* Proportion *by a* Scale *of equal Parts, and ſuch other* Concluſions *as are uſually wrought in* Lines *and* Numbers, *as in Mr.* Gunter's 10 Prob. 2 Chap.

THe *Scale* of *Inches* is a *Scale* of equal Parts, and will perform (by protraction upon a Flat or Paper) ſuch *Concluſions* as are uſually wrought in *Lines* and *Numbers*, as in Mr. *Gunter*'s 10 *Prob.* 2 *Chap. Sector*, may be ſeen, and in others that have writ in the ſame kind. This way Mr. *Samuel Foſter* hath directed in the I *Chap.* of his *Poſthumus Foſteri.*

An Example *in* Numbers *like his Tenth* Probl.

As 16 *to* 7: *So is* 8 *to what?*

Here becauſe the ſecond *Term* is leſs than the firſt, upon the *Line* A B, I ſet A C the firſt *Term* 16, and the ſecond *Term* A D 7, both taken out of the *Scale* of equal parts: thence alſo the third *Number* 8 being taken, with it upon the *Center* C, I deſcribe the *Arke* E F, and from A draw the *Line* A E, which may only touch the ſame *Arke*; then from D, I take D G, the leaſt diſtance from the *Line* A E, and the ſame meaſured in the ſame *Scale* of equal parts, gives 3 $\frac{1}{2}$, the fourth *Term* required.



But if the ſecond *Term* ſhall be greater than the firſt, then the form of working muſt be changed, as in the following *Example.*

EXAMPLE.

As 7 *to* 16: *So* 21 *to what?* ——48.

Upon the *Line* A B, I ſet the ſecond *Term* 16, which is here ſuppoſed to be A D; then with the firſt *Term* 7 upon the *Center* D, I deſcribe the *Arke* G H, and draw A G that may juſt touch it: Again, having taken 21 out of the ſame *Scale*, I ſet one Foot of that Extent upon the *Line* A B, removing it until it fall into ſuch a place, as that the other Foot being turned about, will juſtly touch the *Line* A G before-drawn; and where (upon ſuch Conditions) it reſteth, I make the *Point* C; then meaſuring A C upon your *Scale*, you ſhall find it to reach 48 Parts, which is the fourth *Number* required.

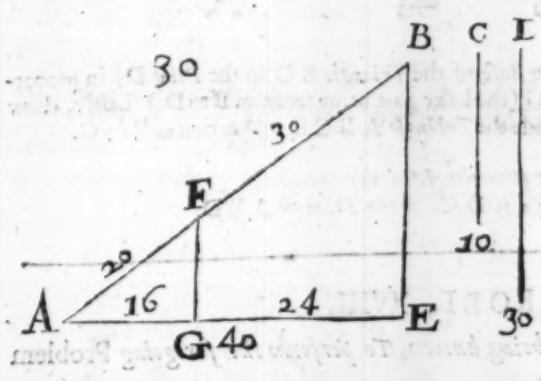
The form of *Works* (although not ſo *Geometrical*) is here given, becauſe it is here more expedite than the other by drawing *Parallel Lines*; but in ſome Practice the other may be uſed. I have been the more large upon this, becauſe in the following Treatiſe

Treatiſe I ſhall quote ſome more remarkable Places in *Poſthuma Foſteri*: and the Solution of *Proportions* muſt be referred thither, the form of their Operations being the ſame with this. In them therefore ſhall only be intimated what muſt be done in general, the particular way of working being here directed.

PROBL. XVI.

To divide a Right Line *given, into two parts, which ſhall have ſuch proportion one to the other as two given* Right Lines.

THe *Line* given is A E, and it is required to divide the ſame into two parts, which ſhall have ſuch proportion one to the other, as the *Line* C hath to the *Line* D.



Firſt, From the *Point* A draw a *Right Line* at pleaſure, making the *Angle* B A E; then take in your *Compaſſes* the *Line* C, and ſet it from A to F; and alſo take the *Line* D, and ſet it from F to B, and draw the *Line* B E: Then from the *Point* F draw the *Line* F G, parallel to B E, cutting the given *Line* A E in the *Point* G: So is the *Line* A B divided into two parts in the *Point* G, in proportion to the other, as the *Line* C is to the *Line* D.

Arithmetically, let the *Line* A E contain 40 Perches or Foot, and let the *Line* C be 20, and the *Line* D 30 Perches; and let it be required to divide the *Line* A E into two parts, being in proportion one to the other, as the *Line* C is to the *Line* D.

Firſt, Add the *Lines* C and D together, their Sum is 50: Then ſay by the *Rule* of *Proportion*, If 50 (which is the Sum of the two given *Terms*) give 40, the whole *Line* A E; What ſhall 30 the greater given *Term* give? Multiply and divide, and you ſhall have in the Quotient 24 for the greater part of the *Line* A E; which being taken from 40, there remains 16 for the other part A G: For

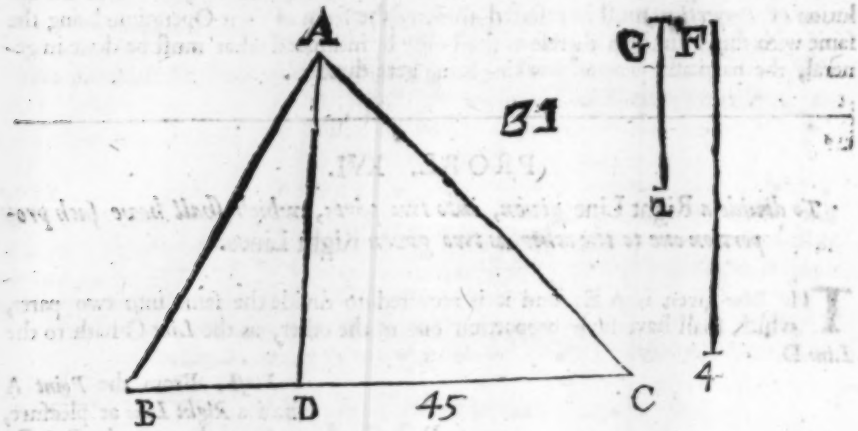
As A B *is to* A E: *So is* B F *to* E G.

50	40	30	24
		40	
		00	
		120	
		1200	

PROBL. XVII.

How to divide a Triangle *into two parts, according to any proportion aſſigned, by a* Line *drawn from any* Angle *thereof; and to lay the leſſer part unto any Side aſſigned.*

LEt A B C be a *Triangle* given, and let it be required to divide the ſame by a *Line* drawn from the *Angle* A, into two parts, the one bearing proportion to the other, As the *Line* F to the *Line* G; And that the leſſer part may be towards the Side A B.



By the laſt *Problem* divide the *Baſe* of the *Triangle* B C in the *Point* D, in proportion as the *Line* F is to the *Line* G (the leſſer part being ſet from B to D.) Laſtly, draw the *Line* A D, which ſhall divide the *Triangle* A B C in proportion as F to G.

As the Line F; *is to the Line* G:
So is the Triangle A D C, *to the Triangle* A B D.

PROBL. XVIII.

The Baſe *of the* Triangle *being known, To perform the foregoing* Problem *Arithmetically.*

Suppoſe the *Baſe* of the *Triangle* B C be 45, and let the Proportion into which the *Triangle* A B C is to be divided, be as 2 to 4. Firſt add the two proportional *Terms* together, 2 and 4, which makes 6; then ſay by the *Rule* of *Proportion*, If 6, the Sum of the Proportional *Term*, give 45 (the whole *Baſe* B C) What ſhall 4 the greater *Term* given? Multiply and divide, and the Quotient will give you 30, for the greater *Segment* of the *Baſe* D C, which being deducted from the whole *Baſe* 45, there will remain 15 for the leſſer *Segment* B D.

As $\frac{2}{4}$ 6 *is to* 45 : *So is* 4 D C 30.

4
180

ꝏ
x8ꝏ (39
ϐϐ

PROBL. XIX.

How to divide a Triangle (*whoſe* Area *or* Content *is known*) *into two Parts, by a* Line *drawn from an* Angle *aſſigned, according to any Proportion required.*

Let the *Triangle* A B C contain 9 *Acres*, and let it be required to divide the ſame into two Parts, by a *Line* drawn from the *Angle* A, the one to contain 5 *Acres*, and the other 4 *Acres*. *Firſt*, meaſure the whole length of the *Baſe*, which ſuppoſe 45; Then ſay, If 9 *Acres* the quantity of the whole *Triangle*, give 45 the whole *Baſe*, What parts of the *Baſe* ſhall 4 *Acres* give? Multiply and divide, the Quotient will

will be 20 for the leſſer *Segment* of the *Baſe* B D; which being deducted from 45 the whole *Baſe* D C, then draw the *Line* A D, which ſhall divide the *Triangle* A B C according to the proportion required.

If 9 Acres give 45, What ſhall 4 Acres give?

Anſwer 20 4

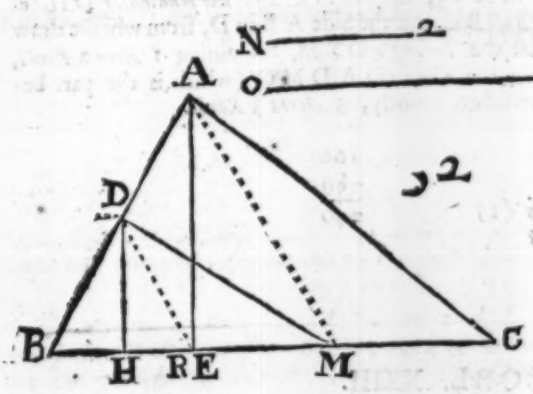
180

180 (20

99

PROBL. XX.

How to divide a Triangle ***given into two parts, according to any Proportion aſſigned, by a*** Line ***drawn from a*** Point ***limited in any of the Sides thereof; and to lay the greater or leſſer part towards any*** Angle ***aſſigned.***



THe *Triangle* given is A B C, and it is required from the *Point* M to draw a *Line* that ſhall divide the *Triangle* into two parts, being in proportion one to the other, as the *Line* N is to the *Line* O; and to lay the leſſer part towards B.

Firſt, from the limited *Point* M draw a *Line* to the oppoſite *Angle* at A; then divide the *Baſe* B C in proportion as O to N, which Point of Diviſion will be at E; then draw E D parallel to A M: Laſtly, from D draw the *Line* D M, which will divide the *Triangle* into two parts, being in Proportion one to the other, as the *Line* O is to the *Line* N.

PROBL. XXI.

To perform the foregoing Problem *Arithmetically.*

IT is required to divide the *Triangle* A B C, from the *Point* M, into two parts in proportion as 5 to 2.

Firſt divide the *Baſe* B C according to the given Proportion; then becauſe the leſſer Part is to be laid towards B, meaſure the diſtance from M to B, which ſuppoſe 32: Then ſay by the *Rule* of *Proportion*, If M B 32, give E B 16, what ſhall A R 28 (*Perpendicular* of the *Triangle*) give? Multiply and divide, the Quotient will be 14, at which diſtance draw a *Parallel Line* to B C, namely D; then from D draw the *Line* D M, which ſhall divide the *Triangle* according to the required Proportion.

PROBL.

PROBL. XXII.

How to divide a Triangle *(whoſe* Area *or* Content *is known) into two Parts, by a* Line *drawn from a* Point *limited, into any Side thereof, according to any number of* Acres, Roods, *and* Perches.

IN the foregoing *Triangle* A B C, whoſe *Area* or *Content* is 5 *Acres* 1 *Rood*, let the limited *Point* be M in the *Baſe* thereof; and let it be required from the *Point* M to draw a *Line* which ſhall divide the *Triangle* into two parts between *Johnſon* and *Powell*, ſo as *Johnſon* may have 3 *Acres* 3 *Roods* thereof, and *Powell* may have 1 *Acre* and 2 *Roods* thereof.

Firſt, Reduce the quantity of *Powell's*, being the leſſer, into *Perches* (Obſerve, 160 ſquare *Poles* contains 1 *Acre*, half an *Acre* contains 80 *Perch*, a quarter or one *Rood* 40 *Perch*.) which makes 240. Then conſidering on which ſide of the limited *Point* M this part is to be laid, as towards B, meaſuring the part of the *Baſe* from M to B 32 *Perch*, whereof take the half, which is 16, and thereby divide 240, the Parts belonging to *Powell*, the Quotient will be 15, the length of the *Perpendicular* D H, at which Parallel-diſtance from the *Baſe* B C, cut the Side A B in D, from whence draw the *Line* D M, which ſhall cut off the *Triangle* D B M, containing 1 *Acre* 2 *Roods*, the part belonging to *Powell*: Then the *Trapezia* A D M C (which is the part belonging to *Johnſon*) contains the reſidue, namely, 3 *Acres* 3 *Roods*.

3	160
28	80
240 (15	240
160	
1	

PROBL. XXIII.

How to divide a Triangle *according to any Proportion given, by a* Line *drawn parallel to one of the* Sides *given.*

THE following *Triangle* A B C is given, and it is required to divide the ſame into two Parts, by a *Line* drawn parallel to the *Side* A C, which ſhall be in proportion one to the other, as the *Line* I is to the *Line* K.

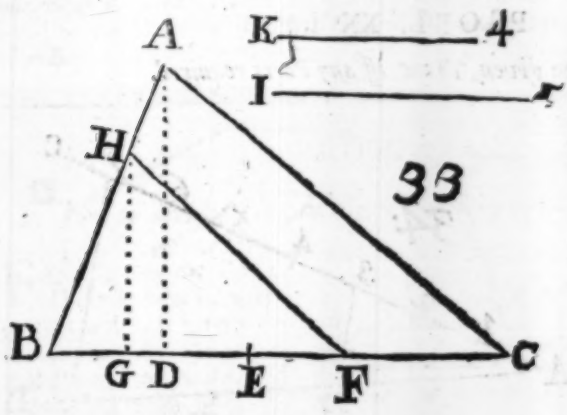
Firſt (by the 16th *Problem*) divide the *Line* B C in E, in proportion as I to K; then (by the 27th *Problem* following) find a mean Proportional between B E and B C, which let be B F, from which *Point* F draw the *Line* F H, parallel to A C, which *Line* ſhall divide the *Triangle* into two parts, *viz.* the *Trapezia* A H F C, and the *Triangle* H F B, which are in proportion one to the other, as the *Line* I is to the *Line* K.

PROBL. XXIV.

To perform the foregoing Problem *Arithmetically.*

LET the *Triangle* be A B C, and let it be required to divide the ſame into two parts, which ſhall be in proportion one to the other, as 4 to 5, by a *Line* drawn Parallel to one of the *Sides*.

Firſt



First let the *Base* B C, containing 54, be divided according to the proportion given; ſo ſhall the leſſer *Segment* B E contain 24, and the greater E C 30; Then find out a mean Proportional between B E 24, and the whole *Base* B C 54, by multiplying 54 by 24, whoſe Product will be 1296; the Square Root thereof is 36, the mean Proportional ſought, wch is B F. Now if B F 36 give B E 24, what ſhall A D 36? The Anſwer is H G 24, at which diſtance draw a *Parallel Line* to the *Baſe*, to cut the *Side* A B in H, from whence draw the *Line* H F, *Parallel* to A C, which ſhall divide the *Triangle* as was required.

54
24
216
108
1296

1296

PROBL. XXV.

To divide a Triangle *of any known Quantity into two Parts, by a* Line *Parallel to one of the* Sides, *according to any Number of* Acres, Roods, *and* Perches.

THe *Triangle* given is A B C, whoſe Quantity is 8 *Acres*, 0 *Roods*, and 16 *Perches*; and it is deſired to divide the ſame (by a *Line* drawn up parallel to the *Side* A C) into two Parts, *viz.* 4 *Acres*, 2 *Roods*, 0 *Perches*; and 3 *Acres*, 2 *Roods*, and 16 *Perches*.

First, Reduce both Quantities into *Perches* (as it is hereafter taught) and they will be 720, and 576; then reduce both theſe Numbers by abbreviation into the leaſt proportional *Term*, *viz.* 5 and 4; and according to that proportion, divide the *Baſe* B C 54 of the given *Triangle* in E: then ſeek the mean Proportion between B E and B C, which Proportion is B F 36, of which 36 take the half, and thereby divide 576, the leſſer Quantity of *Perches*, the Quotient will be H G 32, at which Parallel-diſtance from the *Baſe*, cut off the *Line* A B in H, from whence draw the *Line* H F parallel to the *Side* A C, which ſhall divide the *Triangle* given, according as it was required.

2
2)0
576 (32
288
2

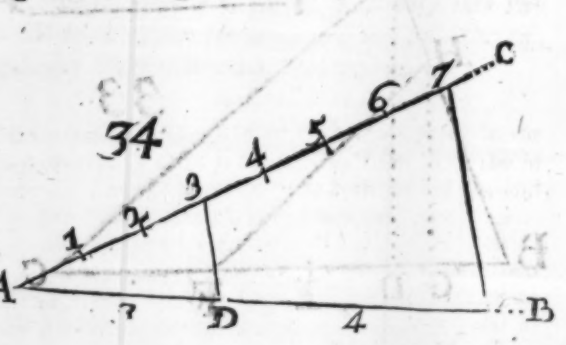
PROBL.

PROBL. XXVI.

From a Line *given, To cut off any Parts required.*

THe *Line* given is A B, from which it is required to cut off $\frac{3}{7}$ Parts.

First, draw the *Line* A C, making any *Angle*, as C A B; then from A set off any 7 equal Parts, as 1, 2, 3, 4, 5, 6, 7; and from 7 draw the *Line* 7 B. Now because $\frac{3}{7}$ is to be cut off from the *Line* B, therefore from the *Point* 3, draw the *Line* 3 D, parallel to 7 B, cutting the *Line* A B in D; So shall A D be the $\frac{3}{7}$ of the *Line* A B, and D B shall be $\frac{4}{7}$ of the same *Line*.



As 7 *is to* A B: *So is* A 3 *to* A D.

PROBL. XXVII.

To find a Mean Proportional *between two* Lines *given.*

IN the following *Figure*, let the two *Lines* given be A and B, between which it is required to find a *Mean Proportional*. Let the two *Lines* A and B be joyned together in the *Point* E, making one *Right Line* as C D, which divided into two equal Parts in the *Point* G; upon which *Point* G, with the distance G C or G D, describe the *Semicircle* C F D: Then from the *Point* E, where the two *Lines* are joyned together, raise the *Perpendicular* E F: So shall the *Line* E F be a *Mean Proportional* between the two given *Lines* A and B. For, *As* E D *is to* E F: *So* E F *to* C F.

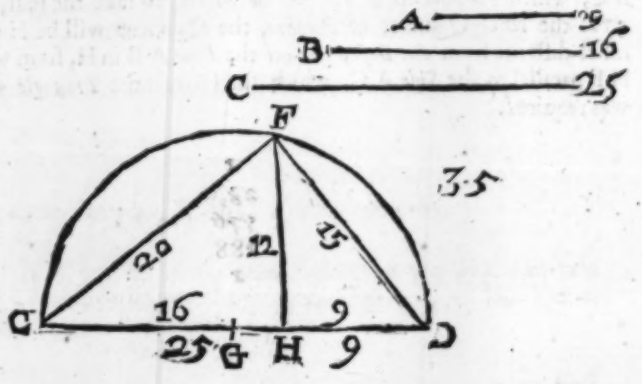
9 12 12 16

PROBL. XXVIII.

How to finde two Lines, *which together shall be equal in Power to any* Line *given; And in Power the one to the other, according to any Proportion assigned.*

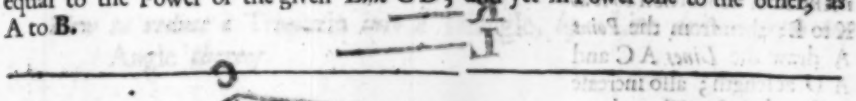
IN this *Figure* let C D be a *Line* given, to be divided in Power, as the *Line* A is to the *Line* B.

First, divide the *Line* C D in the *Point* E, in proportion as A to B (by the 16th *Probl.*) Then divide the *Line* C D into two equal Parts in the *Point* G, and on G, at the distance G D or G C, describe the



Semicircle

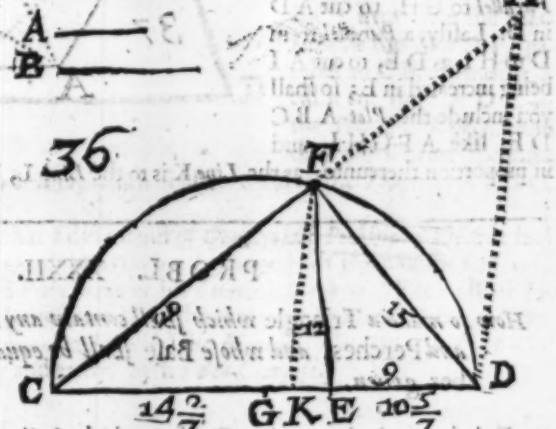
Semicircle C F D, and upon the *Point* E raiſe the *Perpendicular* E F, cutting the *Semicircle* in F. *Laſtly*, draw the *Line* C F and D F, which together in Power will be equal to the Power of the given *Line* C D; and yet in Power one to the other, as A to B.



PROBL. XXIX.

How to divide a Line *in Power according to any Proportion given.*

Firſt, Divide the *Line* C D in the *Point* E, in proportion as A to B: Then divide the *Line* C D in two equal Parts in the *Point* G, and upon G as a *Center*, at the diſtance C D, deſcribe the *Semicircle* C F D, and on E raiſe the *Perpendicular* of E F, cutting the *Semicircle* in F: Then draw the *Line* C F and D F, and produce the *Line* C F to H, till F H be equal to F D, and draw the *Line* D H. *Laſtly*, draw the *Line* F K, parallel to D H: Then ſhall the *Line* C D be divided in K; ſo that the *Square* of C K, ſhall be to the *Square* of K D, as C E to E D, or as B to A.



PROBL. XXX.

How to enlarge a Line *in Power, according to any Proportion aſſigned.*

IN the *Diagram* of the 28th *Problem*, let C E be a *Line* given, to be enlarged in Power as the *Line* B to the *Line* C.

Firſt (by the 16th *Problem*) find a *Line* in proportion to the given *Line* C E, as B is to C, which will be C D; upon which *Line* deſcribe the *Semicircle* C F D, and on the *Point* E erect the *Perpendicular* E F: Then draw the *Line* C F, which ſhall be in power to C E, as C to B.

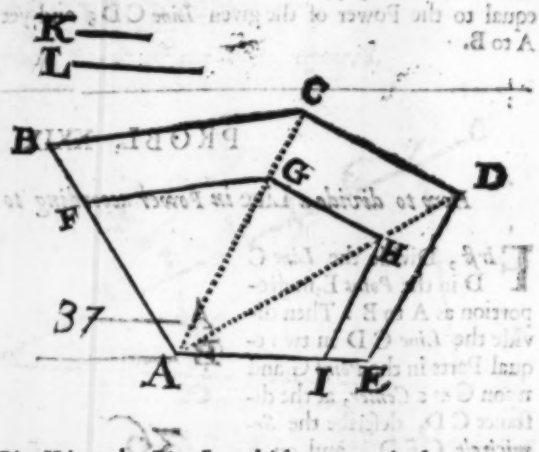
PROBL. XXXI.

To enlarge or diminiſh a Plot *given, according to any Proportion required.*

LEt A B C D E be a *Plot* given, to be diminiſhed in Power as L to K.

Divide one of the *Sides*, as A B in Power as L to K, in ſuch ſort that the Power of A F may be to the Power of A B, as L to K; then from the *Angle* A draw *Lines* to the *Point* C and D. That done, by F draw a *Parallel* to B C, to cut A C in G, as F G: again, from G draw a *Parallel* to D C, to cut A D in H. *Laſtly*, from H draw a *Parallel* to D E, to cut A E in I: So ſhall the *Plot* A F G H I be like A B C D E, and in proportion to it, as the *Line* L to the *Line* K, which was required.

Alſo if the leſſer *Plot* was given, and it was required to make it in proportion to it as K to L; then from the *Point* A draw the *Lines* A C and A D at length; alſo increaſe A F and A I: That done, enlarge A F in Power as K to L, which ſet from A to B; then by B draw a *Parallel* to F G, to cut A C in C, as B C: likewiſe from C draw a *Parallel* to G H, to cut A D in D: Laſtly, a *Parallel* from D to H I, as D E, to cut A I being increaſed in E; ſo ſhall you include the *Plot* A B C D E, like A F G H I, and in proportion thereunto, as the *Line* K is to the *Line* L, which was required.

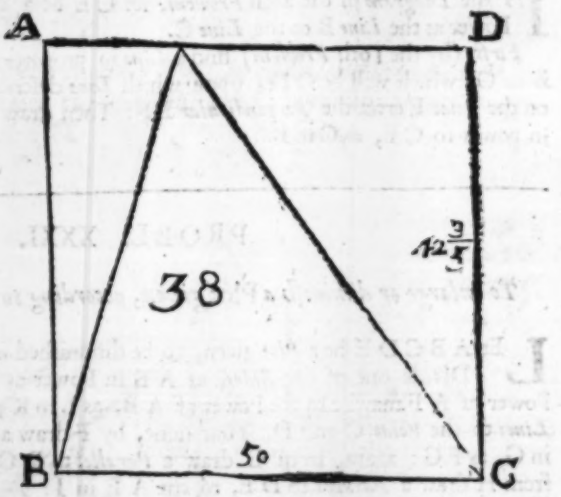


PROBL. XXXII.

How to make a Triangle *which ſhall contain any Number of* Acres, Roods, *and* Perches, *and whoſe* Baſe *ſhall be equal to any* (*poſſible*) Number *given.*

LEt it be required to make a *Triangle* which ſhall contain 6 *Acres*, 2 *Roods*, 25 *Perches*, whoſe *Baſe* ſhall contain 50 *Perches*. You muſt firſt reduce your 6 *Acres* 2 *Roods*, and 25 *Perches*, all into *Perches*, after this manner.

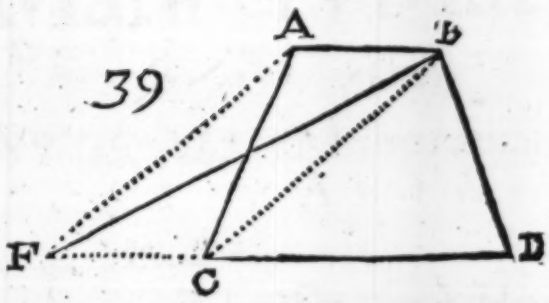
Firſt, Becauſe 4 *Roods* makes 1 *Acre*, multiply your 6 *Acres* by 4. makes 24; to which add the 2 odd *Roods*, ſo have you 26 *Roods* in 6 *Acres* 2 *Roods*; then becauſe 40 *Perches* makes 1 *Rood*, multiply your 26 by 40, which makes 1040, to which add the 25 *Perches*, and you ſhall have 1065, and ſo many *Perches* are contained in 6 *Acres*, 2 *Roods*, and 25 *Perches*.——Now to make a *Triangle* that ſhall contain 1065 *Perches*, and whoſe *Baſe* ſhall be 50 *Perches*, do thus; double the number of *Perches* given, namely 1065, and they make 2130; then becauſe the *Baſe* of the *Triangle* muſt contain 50 *Perches*, divide 2130 by 50, the Quotient will be 42 $\frac{3}{5}$ which will be the length of the *Perpendicular* of the *Triangle*. This done, from any *Scale* of equal Parts, lay down the *Line* B C equal to 50 *Perches*; then upon C raiſe the *Perpendicular* C E, equal to 42 $\frac{3}{5}$ *Perches*, and draw the *Line* A E, parallel to B C; then from any *Point* in the *Line* A E, as from G, draw the *Line* B G, and G C, including the *Triangle* B G C, which ſhall contain 6 *Acres*, 2 *Roods*, 25 *Perches*, which was required.



PROBL.

PROBL. XXXIII.

How to reduce a Trapezia *into a* Triangle, *by a* Line *drawn from any* Angle *thereof.*



THe *Trapezia* given is A B C D, and it is required to reduce the ſame into a *Triangle.*

Firſt, extend the *Line* D C, and draw the *Diagonal* B C; then from the *Point* A draw the *Line* A F, parallel to C B, extending it till it cut the *Side* D C in the *Point* F. *Laſtly,* from the *Point* B draw the *Line* B F, conſtituting the *Triangle* F B D, which ſhall be equal to the *Trapezia* A B D C.

And ſo I have concluded what I did intend of *Geometrical Problems*: Neither had I gone ſo far as I have, in regard Mr. *William Leybourn* hath ingeniouſly and very fully demonſtrated them in his Firſt Book of his *Compleat Surveyor.* But no Book (as I remember) now extant of *Navigation,* hath the foregoing *Problems* ſo large. Beſides, I ſhall direct (in the following *Treatiſe*) the *Mariner* to Survey any *Plantation* or Parcel of Land very exactly and eaſily, by his *Sea-Compaſs.*

The End of the Firſt Book.

A
B
C

THE Mariners Magazine; OR, *STURMY*'s Mathematical and Practical ARTS.

The Second Book.

The ARGUMENT.

YOu're come to see a Sight, *the* World's *the* Stage;
Perhaps you'l say, 'Tis a Star-gazing Age.
Come out and see the Use of Instrument,
Can Speculation *yield you such Content?*
That you can rest in Learning; *But the* Name
Of flying Pegasus, *or swift* Charles-Wain.
And would you learn to know how he doth move
About his Axis, *set at work by* Jove?
If you would learn the Practice, *read, and then*
I need not thus intreat you by my Pen,
To tread in Arts *fair Steps, or gain the way;*
Go on, make haste, Delinquent, *do not stay.*
Or will you scale Olympick *Hills so high?*
Be sure take fast hold on Astronomy;
Then in that fair-spread Canopy no Way
From thee is hid, no not Galaxia.
They that descend the Waters deep, do see
Our great God's Wonders *there, and what they be.*
They that contemplate on the Starry Sky,
Do see the Works *that he hath fram'd so high.*
Then learn the Worlds Division, *and that* Art
Which I shall shew you in this Second Part.

IN this *Book* is contained both a general and particular Description, Making, and Use of all the most necessary *Instruments* belonging to the Art of *Navigation*; As the *Mathematical Ruler*, on which are these *Scales* following; *viz.* The *Line* of *Chords*, *Points*, *Leagues*, *Longitude*, *Natural Sines*, *Tangents*, *Secants*, at one End; at the other is *Dialling Scales*, *viz.* The *Art of Dialling* of all sorts, resolved by the *Chords* and *Gnomon Line*, and *Scale* of Six Hours; *Scale* of Inclination of *Meridians*, and two *Scales* inlarging Hours; *Lines* upon any reclining, inclining, or declining, Plain without a *Center*, called the greater and lesser *Pole*: On the other side is a *Line* of *Artificial Signs*, *Tangents*, and *Numbers*; A *Meridian Line*, according to *Mercator*'s or Mr. *Edward Wright's* Projection; And *Tables* for the making of these *Scales*, with a *Line* of *Longitude* and *Reduction*, which are the *Lines* on the *Mathe-*

matical

matical Scale; alſo, A Portable moſt uſeful *Travis-Scale*, with a *Table* for to make it, with artificial *Rhombs*, *Points*, ½ *Quarters*, and *Tangent-Rhombs*, and the making of the *Sinical Quadrant*, and ſo ordered, that by the help of an *Index*, and *Lines* thereon, it ſhall anſwer moſt of the uſeful Queſtions in *Aſtronomy* and *Navigation*. Alſo the making the plain *Sea-Chard*, and the true *Sea-Chard*, and particular *Chards* for any Place; with the moſt uſeful and neceſſary *Semicircle*, that will protract any *Angle*, or run upon any *Chard*, without drawing *Rhomb-lines* to fill the *Chard*; that ſo, by help of this *Inſtrument*, the *Chard* may ſerve for many Voyages. Alſo the Making and Uſe of a *Compleat Inſtrument*, made in the manner and on the back-ſide of a *Nocturnal*, with 31 of the moſt uſeful and eaſieſt *Stars* to be known in the *North* and *South Hemiſphere*, of the firſt, ſecond, and third Magnitude; which in a Moment, the *Inſtrument* being rectified, ſheweth the Hour of the Night that any *Star* cometh to the *Meridian*, with his Declination *N.* and *S.* Alſo a *Table* of the *Declination*, *Right Aſcenſion*, *Latitude*, and *Longitude* calculated from *Tycho*'s *Tables*, rectified for the year 1671. On the other ſide a *Nocturnal* ſo ordered, that it ſhall give you the Hour of the Night by the *North-Star*, and the brighteſt *Guard*, and his bearing every *Point* of the *Compaſs* from the *Pole*, whereby you may take the true *Declination*; and alſo being ſo rectified, ſheweth the *Suns* place in each *Sign* and *Degree* in the *Ecliptick* every day in the year. The Making and the Uſe of the *Croſs-ſtaff*, *Back-ſtaff*, *Quadrant*; The Making and Uſe of the ſmall *Pocket-Inſtrument*, on which is contained the moſt uſeful *Lines*, *Scales*, and *Proportions*, that in an Inſtant will ſhew the *Diameter* of any ſort of *Ordnance* at the Bore, and the length and weight of the *Gun*, and *Shot*, and *Powder*, in *Braſs* or *Iron*; and the *Diameter* and *Names* of each *Piece*, *Diameter* of the *Shot* to each *Piece*, and the weight of any *Iron Shot*, the *Diameter* being given in *Inches*, with the breadth and length of the *Ladle*; And how many Paces point-blank any *Piece* will ſhoot, and of *Randoms* for the ſixth *Point* of the *Quadrant*, which may by this *Inſtrument* be anſwered near enough for ſo ſhort a time, to give any reaſonable Man an anſwer to any uſeful Queſtion in the *Art* of *Gunnery*. Alſo the Deſcription of the *Mariners Azimuth-Compaſs*, ſo ordered that it ſhall meaſure all kind of Grounds whatſoever, whether Wood-land or other; and for taking of Heights and Diſtances, whether acceſſible or inacceſſible: And by the help of the aforeſaid *Semicircle*, to protract any *Plot* of a *Field* or *Plantation* whatſoever, as ſoon as any *Inſtrument*, as the *Plain Table*, the *Theodolit* or *Circumferenter*, with much delight and pleaſure to the Ingenious *Mariner*, it agreeing ſo well with his *Traviſſes* at *Sea*. All which ſhall be ſhewn in the following *Treatiſe* in its due Place.

A DESCRIPTION OF INSTRUMENTS.

Chap. I.

Of Inſtruments *in general.*

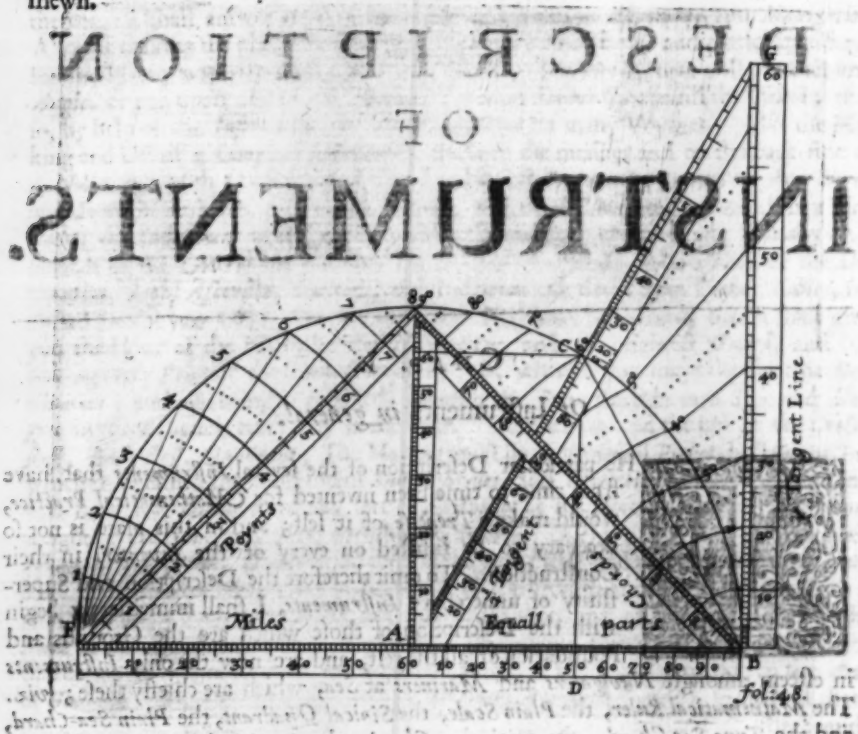
THe particular Deſcription of the ſeveral *Inſtruments* that have from time to time been invented for *Mathematical Practice*, would make a *Treatiſe* of it ſelf; and in this place is not ſo neceſſary to be inſiſted on every of the *Inventors* in their Conſtruction. To omit therefore the Deſcription and Superfluity of unneceſſary *Inſtruments*, I ſhall immediately begin with the Deſcription of thoſe which are the Grounds and Foundation of all the reſt, and are now the only *Inſtruments* in eſteem amongſt *Navigators* and *Mariners* at *Sea*, which are chiefly theſe; *viz.* The *Mathematical Ruler*, the *Plain Scale*, the *Sinical Quadrant*, the *Plain Sea-Chard*, and the *True Sea-Chard*, the particular *Chard*, the *Semicirele* or *Protractor*, the *Nocturnal*, the *Croſs-ſtaff*, *Back-ſtaff*, and *Quadrant*; the *Gunter's Scale*, and the *Mariner's Azimuth-Compaſs*. Now as I would not confine any Man to the Uſe of any particular *Inſtrument* for all *Imployments*; ſo I would adviſe any Man not to incumber himſelf with Multiplicity, ſince theſe aforeſaid are ſufficient for all Occaſions. Theſe ſpecial *Inſtruments* have been largely deſcribed already by divers; As namely, by Mr. *Blundevil*, Mr. *Wright*, Mr. *Gunter*, and others: but not fitted with *Tables* for the making of them, or demonſtrated ſo plain to the Capacities of *Seamen*, as they are here. Therefore in this place it will be very neceſſary to give a particular Deſcription of them, becauſe that if any Man hath a deſire to any particular *Inſtrument*, he may give the better direction for the making thereof, or making of it himſelf.

Foraſmuch as there is a continual uſe both of *Scales* and *Chords*, which are on the *Mathematical Scale*, in drawing of *Schemes* in the Art of *Navigation*, and all other ſorts in this *Treatiſe*; Therefore we will demonſtrate the fundamental *Diagram* of the *Mathematical Scale*, that all *Mariners* may underſtand (that have not the knowledge already) the making of them, which is a moſt commendable Vertue in an expert *Mariner*. I could wiſh that all *Maſters* and *Mates* were able to make their own *Inſtruments*, that if they ſhould be long at *Sea*, and by diſaſter break or loſe their *Inſtruments*; or if any in the Ship diſcovers the Practice, he may be able to make more for himſelf and others, without the help of the *Artificer's* Labour, and ſupply that defect by their own pains.

This *Diagram* plainly ſheweth the making of the *Scale* of *Degrees* or *Chords*, and Points of the *Mariner's Compaſs*, in a *Right Line* B 8, being the *Degrees*, containing in all 90; and F 8 is the *Scale* for the *Points* of the *Compaſs*, being in all 8 *Points* for the $\frac{1}{8}$ part of the whole *Circle*.

Now for the *Sines*, *Tangents*, and *Secants*, you ſhall note, That the *Semi-diameter* A B muſt be divided into a *Radical Number*, for the more eaſe in Calculation; as into 100, or 1000, 10000, 100000; and that by the *Table* of *Natural Sines*, *Tangents*,

Tangents, *Secants*, *Chords*, and *Points*, which I have fitted on purpose for this Work. You may take off so many *Numbers* as the *Table* directs you, as shall be shewn.



Here followeth a *Table* of 90 *Degrees* of the *Quadrant*. He that desires it larger, may make it to the Parts of a *Degree*. I have joyned the *Chord* proper to it, which is the *Natural Sine* of half the *Arch* doubled.

For *Example*, If you double the *Natural Line* of 6. 15. 25. 30 *Deg.* you shall produce the *Chords* of 12. 30. 45. 60 *Degrees*; thus 10453 is the *Sine* of 6 *Degrees*, being doubled, the Sum will be 20906 the *Chord* of 12 *Degrees*; and so of the rest, as in the *Table* following.

The Table *of* Degrees *and* Chords.

De	Chord	De	Chord	De	Chord	De	Chord	De	Chord	De	Chora
01	17	16	278	31	534	46	781	61	1015	76	1231
02	25	17	296	32	551	47	797	62	1030	77	1245
03	52	18	313	33	568	48	813	63	1045	78	1259
04	70	19	330	34	585	49	830	64	1060	79	1273
05	87	20	347	35	601	50	845	65	1074	80	1286
06	105	21	364	36	618	51	861	66	1089	81	1299
07	122	22	382	37	635	52	876	67	1104	82	1312
08	139	23	398	38	651	53	892	68	1118	83	1325
09	151	24	416	39	668	54	908	69	1133	84	1338
10	175	25	432	40	684	55	923	70	1147	85	1351
11	192	26	450	41	700	56	939	71	1161	86	1364
12	209	27	466	42	717	57	954	72	1176	87	1377
13	228	28	484	43	733	58	970	73	1190	88	1389
14	244	29	501	44	749	59	984	74	1204	89	1402
15	261	30	518	45	76	60	1000	75	1217	90	1414

This

This done, Proportion the *Radius* of a *Circle* to what extent you please; make A B equal thereto, which must be divided into equal Parts, as before-directed, by half thereof, and this *Table*, the *Chord* of any *Arch* proportionable to this *Radius*, may speedily be obtained. As for *Example*, Let there be required the *Chord* of *Thirty Degrees*, the *Number* in the *Table* is 518; or in proportion to this *Scale* of 100 equal Parts, A B is 52 almost; I take therefore 52 from the *Scale* of equal Parts, and set them from B towards 8 to *h* and *o*, and draw the *Line h o*, which is the *Chord* desired 30 *Degrees*: Thus may you find the *Chord* of any other *Arch* agreeable to this *Radius*. Or if your *Radius* be of a greater or lesser extent, if you make the *Base* of your *Right Angle* A B equal thereunto, You may in like manner find the *Chord* of any *Arch*, agreeable to any *Radius* given. Only remember, That if the *Chord* of the *Arch* desired exceed 60 *Deg.* A B which is divided into 100 equal parts, you must continue the *Base* A B in the division of such parts, as need shall require.

In this manner is made the *Line* of *Chords* in the *Fundamental Diagram* answerable to that *Radius*.

And in this manner you may find the *Chord* of the *Rhomb*, *Points*, halfs, and quarters, and the *Sines*, *Tangents*, and *Secants* of any *Arch* proportionable to any *Radius*, by help of these *Tables* following [which is an abbreviation of the *Canon* of *Natural Sines*, *Tangents*, and *Secants*] and proportioning the *Base* A B thereunto, which is the *Scale* of equal parts; as by *Example* may more plainly appear.

A Table *for the* Angles *which every* Rhomb *maketh*, *with the* Meridian, *and the* Chords *of every* Quarter *and* Point *of the* Compass.

North.	*South.*	*deg.*	*mi.*	*sec.*	*Chor*	*South.*	*North.*	
		2	48	45	49			
		5	37	30	98			
		8	26	15	147			
N. b. E.	S. b. E.	11	15	00	195	S. b. W.	N. b. W.	1
		14	3	45	244			
		16	52	30	293			
		19	41	15	333			
N. N. E.	S. S. E.	22	30	00	390	S. S. W.	N. N. W.	2
		25	18	45	427			
		28	7	30	485			
		30	56	15	533			
N. E. b. N.	S. E. b. S.	33	45	00	580	S. W. b. S.	N. W. b. N.	3
		36	33	45	627			
		39	22	30	673			
		42	11	15	720			
N. E.	S. E.	45	00	00	767	S. W.	N. W.	4
		47	48	45	811			
		50	37	30	855			
		53	26	15	899			
N. E. b. E.	S. E. b. E.	56	15	00	942	S. W. b. W.	N. W. b. W.	5
		59	3	45	985			
		61	52	30	1028			
		64	41	15	1069			
E. N. E.	E. S. E.	67	30	00	1111	W. S. W.	W. N. W.	6
		70	18	45	1151			
		73	7	30	1190			
		75	56	15	1230			
E. b. N.	E. b. S.	78	45	00	1268	W. b. S.	W. b. N.	7
		81	33	45	1305			
		84	22	30	1343			
		87	11	15	1378			
East.	East.	90	00	00	1414	West.	West.	8

Let there be required the *Chord* of the firſt *Point* of the *Scale*, 11 *Deg.* 15, in this *Table*, as I have fitted for every *Point*, *Half*, and *Quarter*, for ¼ of the *Compaſs*.

The *Numbers* anſwering to 11 *Deg.* 15 *Min.* is 195. I take therefore with my *Compaſſes* 19, or reckon ſo many on the *Scale* of Equal parts, which is joyned with a *Scale* intended to be made; and ſo with a *Square* for that purpoſe, as ſhall be ſhewed, mark from F towards 8 the firſt *Point* 11 *Deg.* 15, where the *Radius* of the *Circle* is A B; and ſo of the reſt.

The Scale *of* Longitude.

THis *Scale* is made alſo by the *Table* of *Degrees* and *Chords*, as before.

EXAMPLE.

It is required to know how many *Miles* make a *Degree* in the *Parallel* of 10 *Deg.* If you extend the *Compaſſes* from A, to the *Complement* of the *Latitude* 80 *Deg.* in the *Line* of *Sines*, and ſetting one Foot in F, turn that diſtance from F toward A, you will find it reach 59 *Miles* neareſt, in the former *Diagram*.

Another EXAMPLE.

It is required in the *Latitude* of 60 *Degrees* to know the *Miles* anſwering to a *Degree*. In that *Parallel* extend the *Compaſſes* from A to the *Complement* of the *Latitude* 30, in the *Line* of *Sines*; and ſetting one Foot of the *Compaſſes* in F, turn that diſtance towards A, and you will find it reach 30 *Miles*, that makes a *Degree* in that *Parallel*; and ſo of the reſt.

But if it be required how to make a *Scale* of *Longitude* in *Miles* anſwerable to the *Radius* of the ſame *Scheme*, for the *Parallel* of 10 *Degrees*, you will find in the *Table*, the *Chord* for 10 *Degrees* is 17.5 for the firſt *Mile*, and for 60 *Degrees* 1000, take 100 from A to B, as you was before directed, and ſo do with the reſt, until you have made the whole *Scale*. Remember, that 60 *Miles* muſt begin where the firſt *Degree* of the *Chords* doth on the *Scale*, and ſo diminiſh towards the *Pole* 90 *Degrees* of the *Scale*, as reaſon will give you.

SINES.

NOte, That a *Sine* falls always within the *Quadrant* of a *Circle*, as C D, which is the *Sine* of the *Arch* B C 60 *Degrees*; and by the *Table* of *Natural Sines*, to every *Degr.* of the *Quadrant* which I have fitted for this purpoſe, whoſe *Radius* is 1000, you ſhall find the *Sine* of 60 *deg.* to be 86.6. I take therefore with my *Compaſſes* 86 from my *Scale* of *Equal Parts*, and ſet them from A towards 8 in the *Line* of *Sines* for 60 *Degrees*, where the *Radius* of the *Circle* is A B, and C E is the *Complement* thereof, or *Sine* of 30 *Degrees* of the *Arch* C 8, the *Number* in the *Table* anſwering 30 *Degrees* is 500; take therefore with your *Compaſſes* 50 equal Parts of A B, and lay it from A upon the *Line* of *Sines* for 30 towards 8; and ſo of the reſt.

A Table *of* Natural Sines *to the* Radius *of* 1000.

De	*Sines.*	*De*	*Sines.*	*De*	*Sines.*	*De*	*Sines.*	*De*	*Sines.*	*De*	*Sines.*
1	17	16	275	31	515	46	719	61	874	76	970
2	34	17	292	32	529	47	731	62	888	77	974
3	52	18	309	33	544	48	743	63	891	78	978
4	69	19	325	34	559	49	754	64	898	79	981
5	87	20	342	35	573	50	766	65	906	80	984
6	104	21	358	36	587	51	777	66	913	81	987
7	124	22	374	37	601	52	788	67	920	82	990
8	139	23	390	38	615	53	798	68	927	83	992
9	156	24	406	39	629	54	809	69	933	84	994
10	178	25	422	40	642	55	819	70	939	85	996
11	190	26	438	41	656	56	829	71	945	86	997
12	207	27	453	42	669	57	838	72	951	87	998
13	224	28	469	43	682	58	848	73	956	88	999
14	241	29	484	44	694	59	857	74	961	89	999
15	258	30	500	45	707	60	866	75	965	90	1000

TAN-

TANGENTS.

A Table of Natural Tangents to every Degree of the Quadrant.

De	Tan.	De	Tan.	De	Tan.	De	Tan.	De	Tangents.
1	17	19	344	37	753	55	1428	73	3270
2	34	20	363	38	781	56	1482	74	3487
3	52	21	383	39	809	57	1559	75	3732
4	69	22	404	40	839	58	1600	76	4010
5	87	23	424	41	869	59	1664	77	4331
6	105	24	445	42	900	60	1732	78	4704
7	122	25	456	43	932	61	1804	79	5144
8	140	26	487	44	965	62	1880	80	5671
9	158	27	509	45	1000	63	1962	81	6313
10	176	28	531	46	1035	64	2650	82	7115
11	194	29	554	47	1072	65	2144	83	8144
12	212	30	577	48	1110	66	2246	84	9514
13	230	31	600	49	1150	67	2355	85	11430
14	249	32	624	50	1191	68	2475	86	14300
15	267	33	649	51	1234	69	2601	87	19081
16	286	34	674	52	1279	70	2747	88	28336
17	305	35	700	53	1327	71	2904	89	57289
18	324	36	726	54	1376	72	3177	90	0000000
									Infinite.

A *Tangent Line* is always falling without the *Quadrant*, and is drawn at the end of a *Semidiameter* at *Right Angles*, as B 6 in the *Fundamental Diagram*, which is the *Tangent* of the *Arch* B C 60 *Degrees*, as in the *Table* of *Tangents* you ſhall find it to be 1732 equal parts, which take with your *Compaſſes* from A, when you have continued the *Line* beyond B, take 173 parts, and that will reach from B to G, the *Tangent* of 60 *Degrees* in the *Scale*, and 8 H is the *Complement Tangent* 30 *Degrees* 577 parts; therefore take 57 parts, it will reach from B to the length of 30 *Degrees*; and ſo of the reſt.

A SECANT.

A Table of Secants to every Degree of the Quadrant.

De	Sec.	De	Sec.	De	Sec.	De	Sec.	De	Secants.
1	1000	19	1057	38	1269	56	1788	74	3627
2	1000	20	1064	39	1286	57	1836	75	3863
3	1001	21	1071	40	1305	58	1887	76	4133
4	1002	22	1078	41	1325	59	1941	77	4445
5	1003	23	1086	42	1345	60	2000	78	4809
6	1005	24	1094	43	1367	61	2062	79	5240
7	1007	25	1103	44	1390	62	2130	80	5758
8	1009	26	1112	45	1414	63	2202	81	6392
9	1012	27	1122	46	1439	64	2281	82	7185
10	1015	28	1132	47	1466	65	2366	83	8205
11	1018	29	1143	48	1494	66	2458	84	9566
12	1022	30	1154	49	1524	67	2559	85	11473
13	1026	31	1166	50	1555	68	2669	86	14335
14	1030	32	1179	51	1589	69	2790	87	19107
15	1035	33	1192	52	1624	70	2923	88	28653
16	1040	34	1206	53	1661	71	3071	89	57298
17	1045	35	1220	54	1701	72	3236	90	0000000
18	1051	36	1228	55	1743	73	3420		Infinite.
		37	1252						

A *Secant* Line is drawn always from the *Center* of the *Circle*, until it cut the *Tangent Line*; as A G in the foregoing *Diagram* cuts the *Tangent* of the *Arch* B C 60 *Degrees* in G: ſo is A G the *Secant* of 60 *Degrees*, which in this *Table* of *Secants* is found 2000 equal parts; therefore take off ſuch parts as are in proportion to A B 200, it ſhall reach from A to G for the *Secant* of 60 *Degrees*, and A H is the *Complement-Secant*, or *Secant* of the *Arch* 8 C, 30 *Degrees*, which in this *Table* of *Secants* is found to be 1154; therefore take with your *Compaſſes*, or other *Inſtruments*, 115 equal parts, and it ſhall reach from A towards G for the *Secant* of 30 *Degrees*, as you may find by the *Scale* in the *Diagram*.

Verſed Sines.

A *Verſed Sine* is found by ſubſtracting his *Complement-Sine* out of the *Radius*. *Example.* For to know the *Verſed Sine* of 60 *Degrees*, you muſt ſubſtract E C or A D, which is the *Complement* or *Sine* of 30 *Degrees*, *viz.* 500 out of the *Radius* 1000, or *Sine* of 90, A B, the remain will be D B 500, for the *Verſed Sine* of the *Arch* B C 60 *Degrees*. In like manner E 8 will be found 134 for the *Verſed Sine* of the *Arch* C 8, being 30 *Degrees*; and ſo work in like manner for any other *Degree*. The Word *Verſed* is a ſufficient Direction, to let them underſtand, that do not, That the *Degrees* of this *Scale*, or ſort of reckoning, begins at B or F, and continues to 180 *Degrees*, the *Diameter* of the *Circle*, or the *Line* of *Sines Reverſed*, by putting the two beginnings of *Degrees* together of the *Quadrant* or *Scale*, and ſo begin to count at one End; for 80 *Degrees* muſt be placed 10, for 70 *Degrees* 20 *Deg.* and ſo to 180; and of the firſt 90 or middle of the *Scale*, count the *Sun's* greateſt Declination 23 *Degrees* 30 *Min.* towards both ends, that is, 47 *Degrees* aſunder in that diſtance; by the ſide thereof muſt be placed the *Reverſed* ſix *Northern Signes*, according to the *Sun's* Declination, and place in the *Ecliptick* at ſuch Declination: And likewiſe 23 *Degrees* 30 *Min.* the ſpace for dividing the *Reverſed Southern Signes* toward 180; and are reckoned double, as occaſion requireth.

Either of the *Semidiameters* A B or A F, the Sides of the *Quadrant*, you may take the equal diviſions thereof, and make a *Scale* of *Leagues* or *Miles*, or *Equal Parts*, for the demonſtration of all plain *Triangles*, which you cannot be without, having it upon the *Ruler*.

Chap. II.

A Deſcription *of what* Inſtruments *of* Braſs, Steel, Iron, *and* Wood, *you muſt be provided with before you can make* Inſtruments *for* Mathematical Uſes.

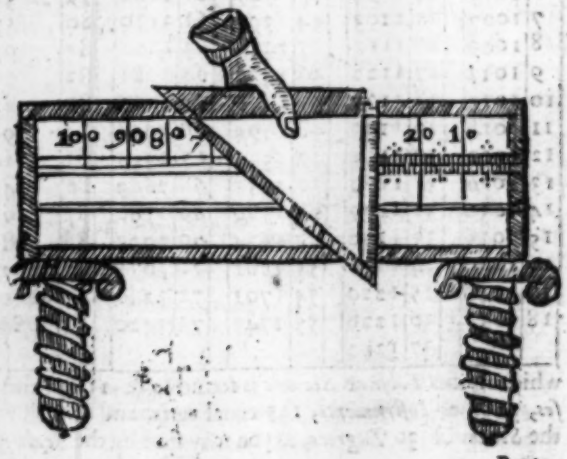
BEfore we explain the other half of the *Fundamental Diagram* and *Semicircle*, it will be neceſſary for to give a Deſcription of what *Inſtruments* in *Braſs*, *Steel*, *Iron*, or *Wood*, you muſt have by you in readineſs, before you can make a *Mathematical Inſtrument*; That Men that are ingenuous may be provided in ſome meaſure with ſuch, before they go to *Sea*, in ſpending their ſpare-time on this *Practice*. In brief, they are theſe. *Firſt*, For *Inſtruments* of *Wood*, you muſt

Scales of equal parts be provided with ſeveral *Scales* of *Equal Parts*, of ſeveral lengths, which muſt be exactly and carefully divided, the length you intend to make the *Radius* of the *Inſtruments* by it. Firſt, divide this *Line* into 10 equal parts, and each 10 into 10 more; ſo is your *Line* divided into 100; and ſo you may continue it into 200, 300, 400, ſo much as you pleaſe, as the *Inſtrument* you are making will require; which you may quickly ſee by the *Table*. You muſt be fitted with ſome

Scales of Box or other Wood. pieces of *Box* (dry, clean from Knots, ſtraight, and ſmooth planed) or other *Wood*, on which you may make what *Scale* you pleaſe. You muſt have by you a true

2 Squares. *Square* of *Braſs* and *Wood*, ſuch as you may ſee in this

2 Cramps. *Figure*, with a pair of *Cramps* made of *Iron*, with *Screws* to faſten the *Scale* of *Equal*



Parts,

Parts, and the *Scale* to be made together, ſo as they may not ſlip, whereby may be made no miſtake in Graduating. Or for ſmall *Scales*, you may faſten the *Scale* of *Equal Parts*, and the *Scale* to be made by it, on a piece of *Deal Board*, with the Heads of *Scuper Nails*, ſo as they will not ſtir; but for greater *Inſtruments*, and *Croſs-ſtaves*, and *Gauging-ſtaves*, you muſt do by them as in this *Figure*. You muſt have a *Gauge* made of *Braſs*, with a good *Steel Pin*, for the drawing of ſtraight *Lines* on your *Scale*, for the diviſion of the *Columnes* for Graduation. You muſt have two or three Sorts and Sets of *Steel Letters* and *Figures*, and *Figures* for Ornament, with a neat *Hammer* to uſe with them: And the *Figures*, and *Letters*, and *Ornament-Figures*, ſet in an *Alphabet-Box*, with written *Letters* and *Figures* before them, for the ready finding of them; with *Characters* of the *Signes*, and *Planets*, and *Stars*, in like manner.

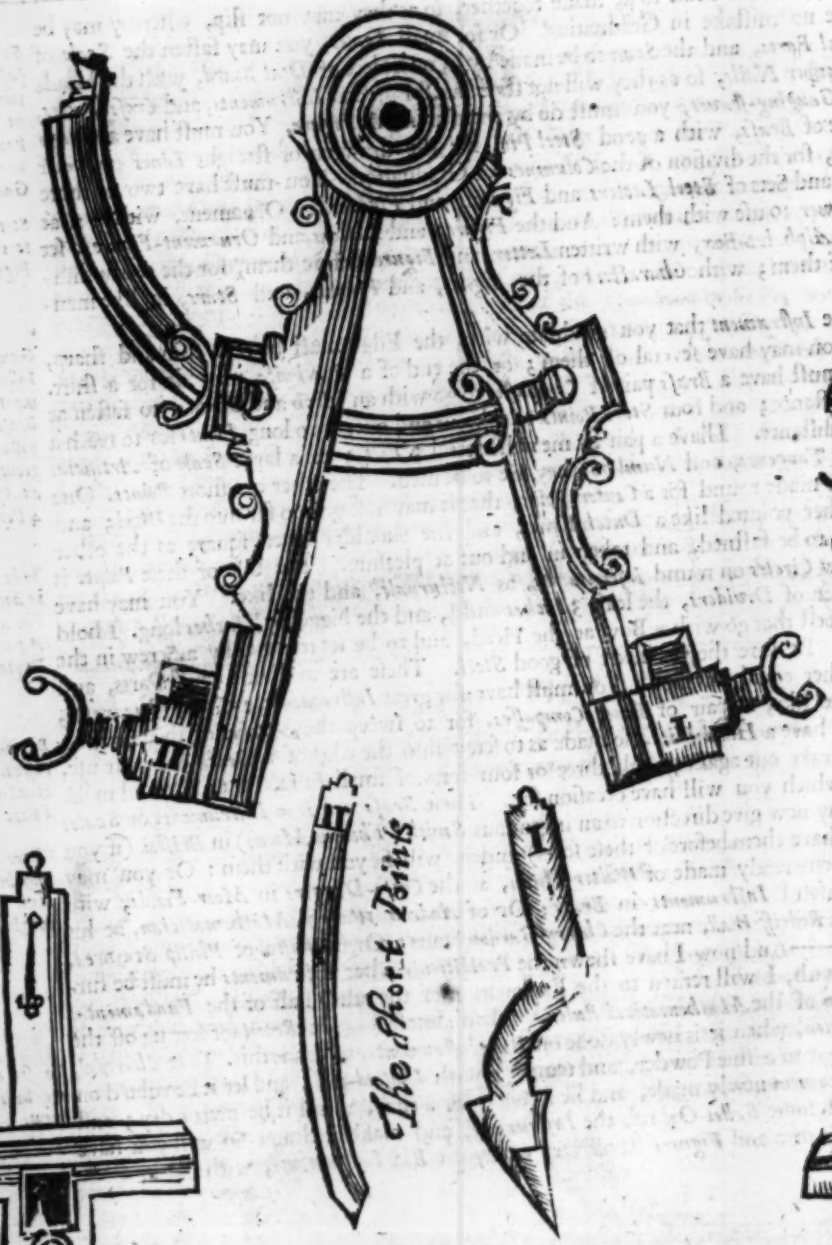
Scales faſtened with Nails, on Deal-Boards.
Braſs a Gauge.
Steel Letters and Figures.

The *Inſtrument* that you graduate with, the Edge muſt be very thin and ſharp, and you may have ſeveral of them; or the end of a *Pen-knife* may do for a ſhift. You muſt have a *Braſs* pair of *Compaſſes* to go with an *Arch* and *Screws*, to faſten at any diſtance; and four *Steel Points* to take in and out; two long *Points* for to reach a great diſtance. I have a pair by me will extend 3 *Foot*, 5 on a large *Scale* of *Artificial Sines*, *Tangents*, and *Numbers*, they are to be uſed. The other are ſhort *Points*. One is to be made round for a *Center-Point*, that it may not go too far into the *Wood*; and the other pointed like a *Dutch* Knife, and the Shoulder fitted ſquare as the other *Points*, to be faſtned, and taken in and out at pleaſure. The Uſe of theſe *Points* is to draw *Circles* on round *Inſtruments*, as *Nocturnals*, and the like. You may have two pair of *Dividers*, the leaſt 3 *Inches* and $\frac{1}{2}$, and the biggeſt $7\frac{1}{2}$ *Inches* long. I hold them beſt that go with a Bow at the Head, and to be ſet together by a Screw in the midſt. Be ſure they be made of good *Steel*. Theſe are to divide equal Parts, and any other equal Diviſion. You muſt have for great *Inſtruments*, as *Bows*, *Quadrants*, and the like, a pair of *Beam-Compaſſes*, for to ſweep the *Arches* of them. You ſhould have a *Hand-Vice*, ſo made as to ſcrew into the edge of a *Board* for your uſe, and to take out again; with three or four ſorts of ſmall *Files*, for to file and make *Pins*, which you will have occaſion for. Theſe *Braſs* and *Iron Inſtruments* or *Scales* you may now give direction to an ingenuous *Smith* (*Thomas Moens*) in *Briſtol* (if you cannot have them before of theſe ſorts) and he will fit you with them: Or you may have them ready made of *Walter Hayes*, at the *Croſs-Daggers* in *Moor-Fields*, with many uſeful *Inſtruments* in *Braſs*; Or of *Andrew Wakely*, *Mathematician*, at his Shop on *Redriff-Wall*, near the *Cherry-Garden* Stairs; Or in *Briſtol* of *Philip Stayned*, *Math.*——And now I have ſhewn the *Practitioner* what *Inſtruments* he muſt be furniſhed with, I will return to the Explanation of the other half of the *Fundamental Diagram* of the *Mathematical Ruler*. I had almoſt forgot a *Receit* for ſetting off the *Graduation*, when it is newly done on *Box-Inſtruments*, which is this. Take *Charcoal*, and beat it to a fine Powder, and temper it with *Linſeed-Oyl*; and let it be rubb'd on the *Inſtrument* newly made, and lie ſo on it for a time, untill it be pretty dry; and then with ſome *Sallet-Oyl* rub the *Inſtrument*, and make it clean: So will you have the *Graduation* and *Figures* ſet off very neatly on *Box Inſtruments*, with Black.

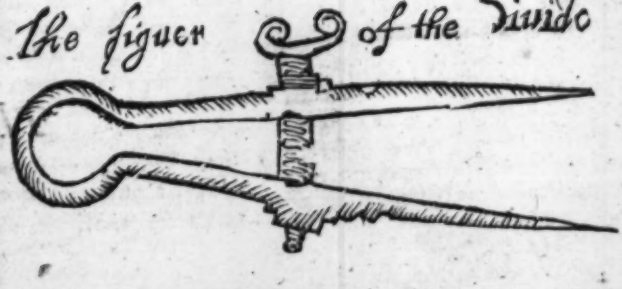
Gauging Inſtruments.
Braſs Compaſſes, together with an Arch & 4 Points.
To be taken in and out.
The uſe.
A pair of Dividers.
Beam-compaſſes.
Hand-vice.
Files.
where they may be made or bought.
To ſet off the Inſtrument.

The

The Figure of the Foure Poynted Compasses



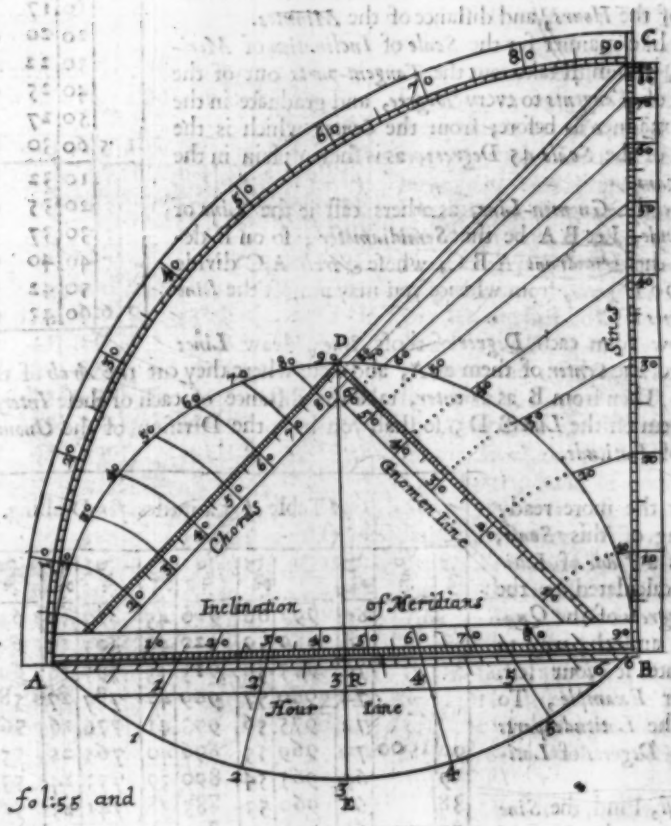
The Figure of ye Gaudge



Chap. III.

The Explanation *of the other half of the former* Semicircle; *being a* Description *of the* Fundamental Diagram, *of the* Dialling-Scale *on the* Mathematical Ruler.

THis annexed *Diagram* sheweth plainly the Description of the *Dialling-Scales* on the *Mathematical Ruler*; It being the most easie and exact *Instrument* used in that *Art*, as by the use will be manifest in the *Seventh Book*.



fol: 55 and

How to make the Diagram.

First, Make a *Semicircle* by a less *Radius*, as A D B, and upon the midst of the *Arch* at D, with the distance D A describe the *Quadrant-Arch*, as A E B, which must be divided into six equal Parts, for the *6 Hours* in the ¼ of the *Sphere*; which is sufficient to resolve the whole; and from each *Point* draw *Lines* to the *Center* at D; So will it cut the *Line* A B in 1, 2, 3, 4, 5, 6, for the *Hour-Lines* upon the said *Scale* for *Dialling*: and thus you see it is a *Tangent Line*, for which use it is more certainly done by this *Table* of *Natural Tangents* for three *Hours*, if you do but observe where the *Right Line* D E cuts the *Tangent Line* A B, which you see in the middle or *Center* of the *Semicircle* at R; therefore you must begin to make this *Scale* in the midst, and lay the distance of parts answering the *Hours* both ways from R towards

wards B and A: As by *Example*, To Graduate 2 *Hours* and 4 *Hours*, you see in the *Table*, the *Numbers* answering to 2 *Hours* and 4 *Hours* in the first *Column* to the left hand, in the second 60 *Minutes*, or in the third 15 *Degrees*, and in the fourth *Column* the *Tangent-parts* 267; therefore if you take 267 such Parts whereof the *Semidiameter* R B is divided into 1000, as was shewed in the former *Diagram*, and put one Foot of the *Compasses* with that extent at R the midst or 3 *Hours*, and turn the other toward B, it will make the distance of 4 *Hours*; and turn that distance towards A, it will be 2 *Hours* of the *Scale*: And so do with the rest of the *Hours*, and distance of the *Minutes*.

In like manner for the *Scale* of *Inclination* of *Meridians*, you must take out the *Tangent-parts* out of the *Table* of *Tangents* to every *Degree*, and graduate in the same manner as before, from the *Center* which is the midst of the *Scale* 45 *Degrees*, as is shewn plain in the *Diagram*.

For the *Gnomon-Line*, as others call it the *Line* of *Latitude*, Let B A be the *Semidiameter*; so on B describe the *Quadrant* A B C, whose *Arch* A C divide into 90 *Degrees*, from whence you may project the *Line* of *Sines* B C.

Now from each *Degree* of those *Sines*, draw *Lines* toward the *Center* of them at A, and note where they cut the *Arch* of the *Quadrant* B D: Then from B as a *Center*, take the distance of each of these *Intersections*, and lay them on the *Line* B D; so shall you have the Division of the *Gnomon-Line*, or *Line* of *Latitude*.

A Table *for the dividing of the* Hours *and* Minutes *upon the* Dialling-Scale.

Ho.	*M.*	*D.*	*Mi.*	*Tan-par.*
3	10	2	30	43
	20	5	00	87
	30	7	30	131
	40	10	00	176
	50	12	30	221
2 4	60	15	00	267
	10	17	30	315
	20	20	00	363
	30	22	30	414
	40	25	00	466
	50	27	30	520
1 5	60	30	00	577
	10	32	30	637
	20	35	00	700
	30	37	30	767
	40	40	00	839
	50	42	30	916
0 6	60	43	00	1000

A Table *of* Latitudes *for* Dialling.

Deg.	*Par.*	*Deg.*	*Par.*	*Deg.*	*Par.*	*Deg.*	*Par.*	*Deg.*	*Par.*	*Deg.*	*Par.*
		80	992	60	926	45	817	30	632	15	354
		78	989	59	920	44	807	29	617	14	332
		76	985	58	915	43	797	28	601	13	310
		74	980	57	909	42	787	27	585	12	288
		72	975	56	903	41	776	26	568	11	265
90	1000	70	969	55	896	40	765	25	551	10	242
89		69	965	54	890	39	753	24	533	9	219
88		68	962	53	883	38	741	23	515	8	195
87		67	958	52	875	37	729	22	496	7	171
86		66	954	51	868	36	717	21	477	6	147
85	998	65	950	50	860	35	704	20	458	5	123
84		64	945	49	852	34	690	19	438	4	98
83		63	941	48	844	33	676	18	419	3	74
82		62	936	47	835	32	662	17	397	2	49
81		61	931	46	826	31	648	16	376	1	25

For the more ready making of this *Scale*, here is a *Table* of *Latitudes* calculated to the 90 *Degrees* of the *Quadrant*, and the way to calculate it your self. As for *Example*, To find the *Latitude-parts* for 30 *Degrees* of *Latitude*,

First, Find the *Sine* thereof in the *Natural Table* of *Sines*, which will be found to be 50000; which sought for in the *Table* of *Tangents*, giveth an *Arch* of 26 *Deg.* 34 *Min.* Then the Proportion will hold, *As the* Radius——100000

To the Secant 45 Deg.——141421

So is the Sine *of* 26 Deg. 34 Min.—— 44724

Unto the Latitude-parts——— 63249

Which answers to the *Radius* 100000: But in my *Table* the *Parts* 632 answer to the *Radius* 1000, which will be sufficient for the Graduating the *Line* of *Gnomons* or *Latitude*.

But observe, To make 30 *Degrees* of *Latitude* on your *Scale*, you must take off

632

632 ſuch Parts as the *Line* is divided into 100, or 1000, as you have been ſhewn in the former *Diagram*.

How to make the *Line* of *Chords*, you have been fully inſtructed already in the former *Figure*; which is only by dividing the *Arch* of the *Quadrant* A D into 90 equal parts; And from A as a *Center*, take the diſtance, and lay them down in a ſtraight *Line* A D: So ſhall you have the *Line* of *Chords* or *Sublemes*. Or you may do it by the *Table* of *Chords*, as before-directed.

How to make the two *Lines* or *Scales* of Inlarging *Hour-Lines* upon any reclining *Plain*, without a *Center*, called by me the greater and the leſſer *Pole*.

Invexed, you have a *Table* ready fitted for the making thereof.

Firſt, You muſt make choice of the length of this *Scale*, that is in Proportion to the former *Lines* of the *Scale*.

A Table *of* Tangents *for* 5 Ho. *to every* 5 Min. *of an* Hour, *for inlarging the* Hour-Line Scale.

Hours.	Mi.	Deg.	Min.	Tan. pa	Hours.	Mi.	Deg.	Min.	Tan. pa
	5	1	15	21		5	46	15	1044
	10	2	30	43		10	47	30	1091
	15	3	45	65		15	48	45	1140
	20	5	00	87		20	50	00	1191
	25	6	15	100		25	51	15	1245
	30	7	30	131		30	52	30	1303
	35	8	45	153		35	53	45	1363
	40	10	00	176		40	55	00	1428
	45	11	15	198		45	56	15	1496
	50	12	30	221		50	57	30	1569
	55	13	45	244		55	58	45	1647
1	60	15	00	267	4	60	60	00	1732
	5	16	15	291		5	61	15	1822
	10	17	30	315		10	62	30	1920
	15	18	45	339		15	63	45	2027
	20	20	00	363		20	65	00	2044
	25	21	15	388		25	66	15	2272
	30	22	30	414		30	67	30	2414
	35	23	45	440		35	68	45	2571
	40	25	00	466		40	70	00	2747
	45	26	15	493		45	71	15	2945
	50	27	30	520		50	72	30	3171
	55	28	45	548		55	73	45	3430
2	60	30	00	577	5	60	75	00	3732
	5	31	15	606					
	10	32	30	637					
	15	33	45	668					
	20	35	00	700					
	25	36	15	733					
	30	37	30	767					
	35	38	45	802					
	40	40	00	839					
	45	41	15	876					
	50	42	30	916					
	55	43	45	957					
3	60	45	00	1000					

The firſt 3 *Hours* muſt be divided into 10 parts, and each of them into 10 more, which ſtand for 100, or as you have been ſhewd for 1000. You muſt have two of theſe *Lines* of *Equal parts*, of two proportionable Lengths, for the greater and leſſer *Pole*; And ſo take of the *Tangent-parts* anſwerable to every 5 *Minutes* of an *Hour*: As you ſee the firſt and ſecond *Columns* of the *Table* are *Hours* and *Minutes*, the third *Degrees*, and the fourth *Tangent-parts*. So the *Tangent* of the firſt 2 *Hours* of the *Scale* or 30 *Degrees*, is 577 *Parts*; take of your two *Scales* 57 *Parts*; Firſt of the largeſt *Radius* for 2 *Hours* on the greater *Scale*, and the like number of the ſmaller *Radius*, or *Line* of *Equal Parts* for 2 *Hours* of the leſſer *Pole-Scale*. And ſo in the ſame manner you muſt work to finiſh the whole *Scales* of what *Radius* you pleaſe, by theſe *Tables*, as hath been directed.

The Uſe hereof is fully ſhewn in the Seventh *Book*, 29th and 30 *Chap.* of the *Art of Dialling*.

Theſe *Scales* are ſufficient to make any ſort of *Dials*, in any *Latitude* (as is there ſhewn) with eaſe and exactneſs.

There are two *Lines* called by the Names of *Style* and *Subſtyle-Scale*; but is only for this *Latitude*, but may be found for any. But the *Scales* before-explained are moſt uſeful, and do the ſame, as you will find in the Seventh *Book* and Twelfth *Chapter* of the *Art of Dialling*. And theſe are the *Scales* of one Side of the *Ruler*.

CHAP. IV.

The Scales *or* Lines *on the Back-ſide of the* Mathematical Ruler, *are theſe*: *A* Line *of* Numbers, *A* Line *of* Artificial Tangents, *A* Line *of* Sines, *A* Meridian Line *according to* Mercator's *or Mr.* Wright's *Projection*; *and the* Scale *of* Equal Parts, *by which the* Numbers *were taken off for the Graduating theſe* Scales; *and a* Line *of* Longitude *or* Equinoctial, *with a* Scale *of* Reduction, *as followeth.*

I. HOw to divide the *Line* of *Numbers* is thus. You muſt prepare a *Ruler* of what length you pleaſe, and alſo a *Scale* of *Equal Parts*, divided into 100 or 1000: You muſt count them. But if you divide the *Artificial Tangents* and *Sines* with the *Line* of *Number*, you were beſt to divide the *Line* into 2000 Parts; ſo will you have 100 on the *Line* of *Numbers*. This *Table* is taken out of the *Logarithms*, by rejecting the *Index* or firſt *Figure*. It is beſt to omit the firſt *Number*, by reaſon they will take up ſo much room; and begin at 1 or 11, and take the *Logarithm-part* at 41 for the firſt 10th or *Integer*. But if you intend to make 100 on your *Line* of *Numbers*, firſt take 100, which is reckoned 1000, as you ſee in the foregoing *Table*, Parts of the *Scale* of *Equal Parts*, for the firſt 10 or middle of the *Scale*: Then ſuppoſe you were to make the firſt 2 or 20, take with your *Inſtrument* or *Compaſs* 301 equal Parts, and lay it from 1 to 2, and the ſame diſtance will reach from 10 in the middle to 20. In the like manner do with the reſt; for 3 or 30 the equal parts is 477, and for 4 or 40, the *Log.* parts is 602: So you may eaſily perceive how to do it, by what is written.

A Table *for the Diviſion of the* Line *of* Artificial Numbers.

Num.	Log. parts.	Num.	Log. parts.	Num.	Log. parts.	Num.	Log. parts.	Num.	Log. parts.
1	00	21	322	41	612	61	785	81	908
2	30	22	342	42	623	62	792	82	913
3	47	23	361	43	633	63	799	83	919
4	60	24	380	44	643	64	806	84	924
5	69	25	397	45	653	65	812	85	929
6	77	26	414	46	662	66	819	86	934
7	84	27	431	47	672	67	826	87	939
8	90	28	447	48	681	68	832	88	944
9	95	29	462	49	690	69	838	89	949
10	100	30	477	50	698	70	845	90	954
11	41	31	491	51	707	71	851	91	959
12	79	32	505	52	716	72	857	92	963
13	113	33	518	53	724	73	863	93	968
14	146	34	531	54	732	74	869	94	973
15	176	35	544	55	740	75	875	95	977
16	204	36	556	56	748	76	880	96	982
17	230	37	568	57	755	77	886	97	986
18	255	38	579	58	763	78	892	98	991
19	278	39	591	59	770	79	897	99	995
20	301	40	602	60	778	80	903	100	1000

II. *How*

II. *How to make the* Line *of* Artificial Tangents *on the* Ruler.

THe *Artificial Tangents* are made in the ſame manner as before directed, beginning upon a *Right Line* of *Numbers*, omitting the firſt 30 *Minutes*, and beginning at 40 *Minutes*. The *Tangent-parts* are 106, taken off the former *Scale*, and applied as before-directed upward, will make 40 *Minutes* on your *Scale*: So the firſt and 89 *Degree*, the *Tangent-part* anſwering thereunto is 241; with them do in like manner, and ſo of the reſt, until you have finiſhed the whole *Line* or *Scale*, as you may ſee in the *Figure*.

The following *Table* is ſo plain to be underſtood, that I need write no more, but, That the firſt *Column* to the left hand is *Minutes*, The ſecond *Tangent-parts* anſwering to the *Minutes* and *Degrees* over each *Column* to 30 *Degrees*, and after to every 20 *Minutes*, as you may ſee in the *Table*.

III. *A* Table *for the Diviſion of the* Line *of* Artificial Tangents *to* 45 Deg. *and the* Minutes *fit to be ſet thereon.*

Minutes.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.	Deg. Tang. parts.
		89	88	87	86	85	84	83	82	81	80	79
	0	1	2	3	4	5	6	7	8	9	10	11
0	00	241	546	719	844	941	1021	1089	1147	1199	1246	1288
10	46	308	577	742	862	956	1033	1099	1156	1207	1253	1295
20	76	366	610	765	879	970	1045	1106	1165	1215	1260	1301
30	96	410	640	786	895	983	1056	1119	1174	1223	1267	1308
40	106	463	668	806	911	996	1067	1129	1183	1231	1274	1314
50	162	505	694	826	927	1009	1078	1138	1191	1238	1281	1321
									70			
Min.	12	13	14	15	16	17	18	19	20	21	22	23
0	1327	1363	1396	1428	1457	1485	1511	1536	1561	1584	1606	1627
10	1333	1369	1402	1433	1462	1489	1516	1541	1564	1587	1610	1631
20	1339	1374	1407	1438	1466	1494	1220	1545	1568	1591	1613	1634
30	1345	1380	1412	1442	1471	1498	1524	1549	1572	1595	1617	1638
40	1351	1385	1417	1447	1476	1503	1528	1553	1576	1599	1620	1641
50	1357	1391	1422	1452	1480	1507	1532	1557	1580	1602	1624	1645
							60					
Min.	24	25	26	27	28	29	30	31	32	33	34	35
0	1648	1668	1688	1707	1725	174.	1761	1738	1795	1812	1828	1845
10	1651	1671	1691	1710	1728	1746						
20	1655	1675	1694	1713	1731	1749	1767	1784	1801	1818	1834	1850
30	1658	1678	1697	1716	1735	1752						
40	1662	1681	1700	1719	1737	1755	1773	1790	1806	1823	1839	1855
50	1665	1684	1704	1722	1742	1758						
					50					45		
Min.	36	37	38	39	40	41	42	43	44	45		
0	1861	1877	1892	1908	1923	1939	1954	1969	1984	2000		
20	1866	1882	1898	1913	1928	1944	1959	1974	1989			
40	1871	1887	1903	1918	1934	1949	1964	1979	1994			

IV. *How to make the* Scale *or* Line *of* Artificial Sines *to* 90 Deg. *and* Minutes *fit to be ſet thereon.*

HOw to make this *Line*, was ſhewn by making the laſt; only that is ſufficient to 45 *Degrees*, and this muſt be to 90 *Degrees*. And if your *Line* of *Equal Parts* be divided into 100, or as they be reckoned 1000, you may omit the laſt *Figure* of the *Number*: But if you number the *Scale* to 2000, as the *Tables* are made to, if you would ſet off the *Sine* of 30 *Degrees*, the *Parts* anſwering thereunto is 1698; therefore take off your *Scale* of *Equal Parts* with your *Compaſſes* 169, and it will reach from the beginning, to 30 *Degrees* on the *Line* of *Sines*.

So I hope you underſtand how to do the reſt, it being made ſo plain and eaſie for the meaneſt Capacity, by what hath been writ already.

A Table

A Table *for the Division of the* Artificial Sines *on the* Ruler.

Minutes.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.	Deg. Sine parts.
	0	1	2	3	4	5	6	7	8	9	10
0	00	241	542	718	843	940	1019	1085	1143	1194	1239
10	46	308	577	742	861	954	1031	1096	1152	1202	1246
20	76	366	609	764	878	968	1042	1105	1161	1209	1253
30	94	417	639	785	894	981	1053	1115	1169	1217	1260
40		463	667	805	910	994	1064	1125	1178	1225	1267
50	162	505	693	825	925	1007	1075	1134	1186	1232	1274
Min.	11	12	13	14	15	16	17	18	19	20	21
0	1280	1317	1352	1383	1412	1440	1465	1489	1512	1534	1554
10	1287	1323	1357	1388	1417	1444	1470	1493	1516	1537	1557
20	1293	1329	1362	1393	1422	1449	1474	1497	1519	1540	1560
30	1299	1335	1368	1398	1426	1453	1478	1501	1523	1544	1564
40	1305	1340	1373	1403	1431	1457	1482	1505	1527	1547	1567
50	1312	1346	1378	1408	1435	1461	1486	1508	1530	1551	1570
Min.	22	23	24	25	26	27	28	29	30	31	32
0	1573	1591	1609	1625	1641	1657	1671	1685	1698	1711	1724
10	1576	1594	1612	1628	1644	1659	1673	1687			
20	1579	1597	1614	1631	1646	1661	1676	1690	1703	1716	1728
30	1582	1600	1617	1633	1649	1664	1678	1692			
40	1585	1603	1620	1636	1652	1666	1680	1694	1707	1720	1732
50	1588	1606	1623	1639	1654	1669	1683	1696			
Min.	33	34	35	36	37	38	39	40	41	42	43
0	1736	1747	1758	1769	1779	1789	1798	1808	1816	1825	1833
20	1739	1751	1762	1772	1782	1792	1801				
40	1743	1754	1765	1776	1786	1795	1805				
Min.	44	45	46	47	48	49	50	51	52	53	54
0	1841	1849	1856	1864	1871	1881	1884	1890	1896	1902	1907
Min.	55	56	57	58	59	60	61	62	63	64	65
0	1913	1918	1923	1928	1933	1937	1941	1945	1949	1953	1957
Min.	66	67	68	69	70	71	72	73	74	75	76
0	1960	1964	1967	1970	1972	1975	1978	1980	1982	1984	1986
Min.	77	78	79	80	81	82	83	84	85	86 87	90
0	1988	1990	1991	1993	1994	1995	1996	1997	1998	1998	2000

V. *How to make a* Meridian Line *according to the true* Sea-Chard, *or* Mercator *and Mr.* Wright's *Projection.*

THis *Line* is made out of the *Table* of *Meridian parts*, called alſo the *Diviſion* of the *Meridian Line*. To every 10 *Minutes* of *Latitude*, nearer we have no *Chards* or *Plots* made, which I have as yet ſeen; but they may be made by Mr. *Wright's Tables* to every *Minute*, if any Perſon will be ſo curious.

For the Graduating this *Line* in the *Scale*, you muſt note the *Number* anſwering to the firſt *Degree* is 200; therefore divide the *Degrees* of the *Æquinoctial* into 20 equal Parts, which ſtand for 200 of the *Numbers* of your *Table*. As by *Example*,

Suppoſe you would make the firſt 10 *Degrees* from the *Æquator*, towards either of the *Poles*, on the *Scale*; the *Number* anſwering 10 *Degrees* is 201, omitting the laſt *Figure* 0: Therefore you may take out of the *Line* of *Longitude* (which is Equal Parts, or the ſame *Line* by which you made all the reſt) 201 or 20 Parts, and lay that diſtance for the beginning of the firſt 10 *Degrees*; and for 20 *Degrees* 40,8; and for 30 *Degrees* 62,93 and ſo of the reſt.

But if you are to make a particular *Line*, you muſt take the difference of the *Degrees* and *Minutes*, as ſhall be fully ſhewn in the *Treatiſe* of making a general and particular *Sea-Chard*, according to Truth, and Mr. *Wright's* Projection; but what hath been done already will ſerve for both, if you follow direction.

There is demonſtrated and ſhewn the making of *Mercator's Scale*, to meaſure Diſtance in any *Parallel* of *Latitude* in any true *Sea-Chart*.

VI. *How to Calculate a* Table, *and by it how to take out the* Numbers, *and make a* Scale *of* Reduction, *to be uſed in Surveying of* Land.

A Table *for the Diviſion of the* Scale *of* Reduction.

	Statute Acres.	
10	272	25
11	255	00
12	189	06
13	161	10
14	138	91
15	121	00
16	106	35
16½	100	00
17	094	21
18	84	03
19	75	42
20	68	7
21	61	73
22	56	25
23	51	47
24	47	27
25	43	56
26	40	27
27	37	35
28	34	73
29	32	37
30	30	25
31	28	33
32	26	59
33	25	00
34	23	55
35	22	21
36	21	1
37	19	89
38	18	85
39	17	90
40	17	02

THis *Scale* conſiſteth of one part or *Line* of *Numbers* and *Artificial Sines* on the *Ruler*, for the more ready uſe thereof, as will be ſhewed: I ſhall firſt ſhew the Calculation and Proportion uſed in making the *Table*, which is thus as followeth.

Example, For a *Perch* whoſe Meaſure is 21 *Foot* (which is the *Iriſh Chain*) this muſt be done by the back *Rule of Three.*

As 16½ *ſquared, to* 100 *Acres:*
So is 21 *ſquared, to* 61,73 *Acres.*

So a piece of Ground being meaſured by the *Statute-Chain* of 16½ *Foot* to the *Perch*, ſhould contain 100 *Acres.*

Then the ſame piece of Ground being meaſured by the *Iriſh Chain* of 21 *Foot*, will contain but 61 $\frac{73}{100}$ *Acres*, as you may ſee in the *Table*, which is near 61 *Acres* 2 *Quarters* 38.

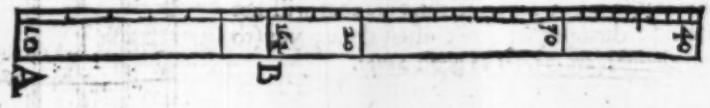
By the *Line* of *Artificial Numbers* extend the *Compaſſes* from 16½ to 21, the ſame will reach twice repeated from 100 unto 61,73 in the ſame *Line* of *Numbers.*

To make this *Line* on the *Scale*, Take the *Numbers* off the *Line* of *Numbers* of the ſame *Scale* you make this *Line* upon.

EXAM-

EXAMPLE.

I ſhall place the firſt 10 on the *Scale*, to this *Number* anſwers 272. 25″; therefore extend the *Compaſſes* from 100 to 272 ¼, or from 27 ½, and lay one Foot of the *Compaſſes* at A, and the other will reach to B the diſtance to 16 ½. From 16 ½ you muſt lay all your other *Numbers*. As ſuppoſe you would ſet down 14 on the *Scale*, the *Statute Numbers* anſwering thereunto is 138 and 91″. Extend the *Compaſſes* from 100 to 138 and 91″, and that diſtance will reach from 16 ½ at B, to 14 of the *Scale*. The like if you would ſet off 20, the *Numbers* to that is 68. 75 and that diſtance will reach from 16 ½ at B, to 20: and ſo do with the reſt. Thus have I done with this *Scale*, being ſufficient to reſolve all manner of *Mathematical Concluſions* whatſoever. The Uſe follows in the ſucceeding *Treatiſe*.



Points.	Nor. South.	Deg. Min.	Sine parts	Tang. Rhomb.	Tang. equ. p
	N. b. E. 1	2 48	688		689
	S. b. E. 2	5 37	990		992
	S. b. W. 3	8 26	1166	1	1177
1	N. b. W. 4	11 15	1290	7	1298
	N. N. E.	14 3	1385		1398
	S. S. E.	16 52	1462		1481
	S. S. W.	19 41	1527	2	1553
2	N. N. W.	22 30	1582	6	1617
	N. E. b. N.	25 18	1630		1673
	S. E. b. S.	28 7	1673		1727
	S. W. b. S	30 56	1710	3	1777
3	N. W. b. N.	33 45	1744	5	1824
	N. E.	36 33	1774		1870
	S. E.	39 22	1802		1914
	N. W.	42 11	1827	4	1957
4	S. W.	45 00	1849	4	2000
	N. E. b. E.	47 48	1869		
	S. E. b. E.	50 37	1890		
	S. W. b. W.	53 26	1904		
5	N. W. b. W.	56 15	1919		
	E. N. E.	59 03	1933		
	E. S. E.	61 52	1945		
	W. S. W.	64 41	1956		
6	W. N. W	67 30	1965		
	E. b. N.	70 18	1973		
	E. b. S.	73 7	1989		
	W. b. S.	75 56	1986		
7	W. b. N.	78 45	1991		
	East & West.	81 33	1995		
		84 22	1997		
		87 11	1999		
		90 00	2000		

CHAP. V.

A Table *for the Diviſion of the* Artificial Rhomb, *or* Points, Halfs, *and* Quarters *on the* Travis-Scale.

THe Uſe of this *Table* is eaſily underſtood: The firſt *Column* is the Number of *Points* in one quarter of the *Compaſs*, and the ſecond their Names in the whole; The third the *Degrees* anſwering to each quarter of a *Point* in the *Quadrant*; The fourth the *Sines* and *Equal Parts* anſwering thereunto; The fifth the *Tangent-Rhombs*; The ſixth the *Tangent-parts* anſwering to each *Quarter* and *Point* to 45 *Degrees* ½, which is ſufficient.

The

The Deſcription of the Travis-Scale.

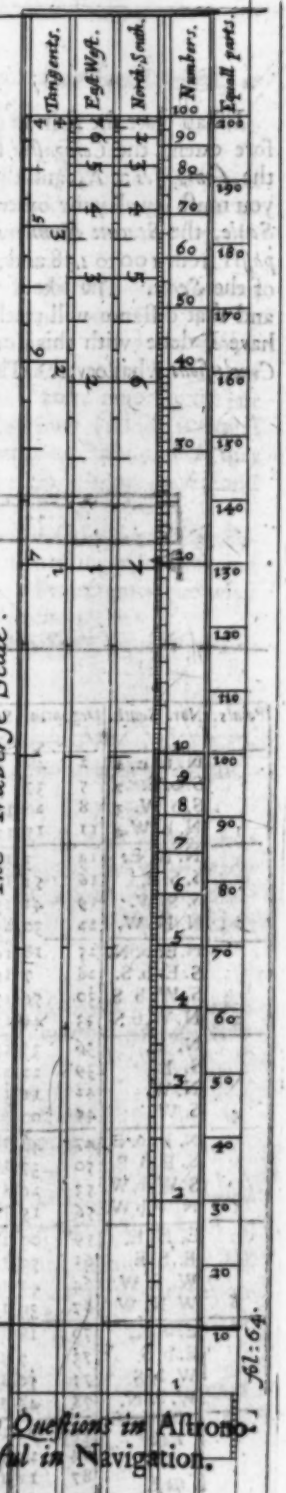
The making of this *Scale* is all one in a manner as you made the former; only the *Line* of *Sines* is there but once made, and here the *Parts* anſwering each *Quarter* are twice put down, or in two *Lines* marked with *N. S.* which ſtands for to ſhew the *Line* to be *Northing*, *Southing*; and *E. W.* ſignifies *Eaſting* and *Weſting*. The firſt is the *Sine*, the ſecond is the *Complement* that any *Point* or *Quarter* maketh an *Angle* with the *Meridian*. The *Line* marked with *T.* is the *Tangent-Rhomb* and *Quarters*, and the firſt *Line* is a *Line* of *Numbers*, which you have been already ſhewn to make.

One *Example* I will give the *Learner*, notwithſtanding it is ſo eaſie; for ſome there are that will not underſtand, though they ſee it often done; yet (to my knowledge) are *Mates* to good *Ships*.

EXAMPLE.

Suppoſe you was to ſet the firſt and ſeventh *Rhomb* or *Artificial Point* on the *Scale*, which is 11 *Degrees* 15 *Minutes*, the *Equal Parts* anſwering thereunto is 1290; therefore take 129 of your *Scale* of *Equal Parts*, and lay it from the beginning upwards, and you have by that diſtance the firſt and ſeventh *Rhomb* of your *Scale*.

In like manner do for any other of the *Points* and *Quarters* by theſe *Numbers*, until you have finiſhed the *Scale*; and when you have done, you have an *Inſtrument* the moſt eaſie, ready, and neceſſary that I know of, for the working of *Traviſes*, and correcting your dead Reckoning, which ſhall be ſhewn in the Part of Sailing by the *Plain Chard*, in the Fourth Book. On the back ſide of this *Scale* you may ſet a *Line* of *Chords* and *Equal Parts*, and *Points*, for the ready protraction of *Angles*.

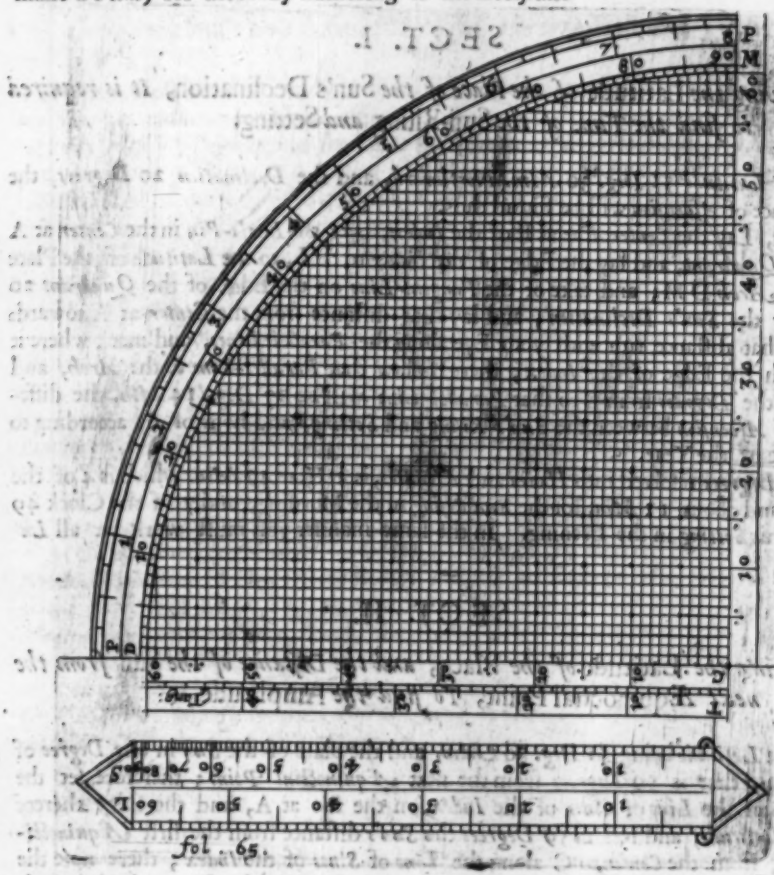


Chap. VI.

How to make a Quadrant *which will reſolve many Queſtions in* Aſtronomy, *by the help of an* Index; *and alſo very uſeful in* Navigation.

After you have made choice of the *Radius* of your *Quadrant* C D, draw *Parallel Circles* thereunto, to hold the *Degrees* of the *Quadrant* and *Columns*, for the *Figures*, *Points*, and *Quarters*, as P 8. Then divide the *Semidiameter* or Side of the *Quadrant* C D and C M into 60 equal parts, and draw *Parallels*

rallel to each of the Diviſions, as Sides, C D and C M. Firſt divide them into 6, and then each of them into 10 more, as you ſee in the *Figure*; at every 5 Parts make a *Point*, for the ready numbring of the *Diviſions*.



Make an *Index* anſwerable to the *Radius* C D, with a *Line* of *Sines* on the firſt Side, and a *Center-Ear* to put over the *Center-Braſs-Pin* of the *Quadrant* C, as occaſion ſhall require: And on the other Edge make a *Line* of *Equal Parts*, equal to the 60 *Diviſions* of the Side C D, with an *Ear* in like manner to remove at pleaſure.

Make on the Edge a *Tangent-Line*; from it you muſt take the *Sun's Declination*, as you ſhall be fully ſhewn in the Uſe thereof.

This *Quadrant* will ſerve excellent well for a *Protractor*, with a long *Index* divided into 100 or 200 Equal Parts, with an *Ear* as the former, and a *Needle* put into a *Stick*, to put through the *Center* of the *Index* and *Quadrant* on any *Point*, in a Plain or *Mercator's Chard*; by which you may Protract any *Rhomb* without drawing *Lines* upon the ſaid *Chard*; as likewiſe the *Protractor* or *Semicircle* which follows may do the ſame, being made in the ſame manner. On the back ſide of the *Quadrant* you may put Mr. *Gunter's* or Mr. *Samuel Foſter's Quadrant*, or any other as you ſhall think fit.

The Uſe of the *Quadrant* in *Aſtronomy*.

SECT. I.

Having the Latitude *of the Place of the* Sun's Declination, *It is required to find the Time of the* Sun-Riſing *and* Setting.

The *Latitude* 51 *Deg.* 30 *Min. Northward*, and the *Declination* 20 *Degrees*, the difference of *Aſcenſion* will be found thus.

Firſt, Lay the *Center Ear* at E of the *Index*, over the *Braſs-Pin* in the *Center* at A of the *Quadrant*, and lay the Edge of the *Index* to E L, to the *Latitude* of the Place on the *Arch* D M; and take of the *Tangent-Line* on the Edge of the *Quadrant* 20 *Degrees* the *Sun's Declination*; and lay that diſtance from the *Center* at A towards D, at that diſtance run with your Eye along the *Parallel-Lines*, and mark where it toucheth the Edge of the *Index*; there follow that *Parallel-Line* to the *Arch*, and reckon the *Degrees* from B to that *Parallel-Line* will be 27 *Deg.* 14 *Min.* the difference of *Aſcenſion* between the *Sun's Riſing* and *Setting*, and hour of 6, according to the time of the Year.

The *Degrees* reſolved into *Hours* and *Minutes*, is 1 *Hour* 49 *Min.* which is 4 of the Clock and about 11 *Min*, for the *Sun Riſing* in the Morning, and 7 of the Clock 49 *Min.* his *Setting* in the Evening. In the ſame manner you muſt work for all *Latitudes*.

SECT. II.

Having the Latitude *of the* Place, *and the Diſtance of the* Sun *from the next* Æquinoctial Point, *To find the* Amplitude.

So the *Latitude* being 51 *Deg.* 30 *Min.* and the place of the *Sun* in one *Degree* of *Aquarius*, that is 59 *Degrees* from the next *Æquinoctial Point*; therefore ſet the *Ear* at S of the *Line* of *Sines* of the *Index* on the *Pin* at A, and the Edge thereof to the *Latitude*, and reckon 59 *Degrees* the *Sun's* diſtance from the firſt *Æquinoctial Point*, from the *Center* to C along the *Line* of *Sines* of the *Index*; there note the *Line* that cuts the 59 *Degrees* following with your Eye, to the *Degrees* in the *Arch*, and reckon the *Minutes* of *Degrees* from M to the Edge of the *Index*, and you will find it about 33 *Deg.* 20 *Min.* the *Amplitude* required.

SECT. III.

Having the diſtance of the Sun *from the next* Æquinoctial Point, *To find his* Declination.

The *Sun* being either in 29 *Degrees* of *Taurus*, or 1 *Deg.* of *Aquarius*, or 1 *Deg.* of *Leo*, or 29 *Deg.* of *Scorpio*, that is 59 *Degrees* from the next *Æquinoctial Point*, To find his *Declination* do thus: Put the *Ear* of the *Line* of *Sines* on the *Pin* and Edge of the *Index*; put to 23 *Deg.* 30 *Min.* in the *Sun's* greateſt *Declination*, reckoned from M on the *Arch*; then count the *Sun's* diſtance 59 *Deg.* on the *Deg.* of *Sines* of the *Index*: From the *Center* put one Foot of your *Compaſſes* by the *Degree*, with the other take the neareſt diſtance to the *Line* or *Side* C M; apply that diſtance in the *Line* of *Sines* of the *Index*, from S along, and the other Foot will reach to 20 *Degrees*, the *Declination* required when the *Sun* is in the aforeſaid *Degrees* and *Sines*. In like manner you muſt do for any other *Degrees* of the *Sun's* Place.

SECT.

SECT. IV.

Having the Latitude *of the* Place, *and the* Declination *of the* Sun, *To find the* Sun's *true* Amplitude *from the true* East *and* West.

This is a most excellent ready way by this *Quadrant*, and as near the Truth as any Man can make any rational use of this *Problem* at *Sea*: It is thus. Suppose the *Latitude* to be 13 *Degrees*, and the *Sun's Declination* 20 *Degrees Northward*, the *Sun's* true *Amplitude* of *Rising* and *Setting* is required, from the true *East* and *West*.

Set the *Ear* of the Side of the *Index* on which is the *Line* of *Sines* on the *Center*, and Edge to the *Latitude* 13; then count from M 20 *Degrees* of *Declination*, and carry your Eye upon the *Parallel-Line* from that *Degree* of the *Arch*, and mark what *Degree* it cuts of the *Index* and *Line* of *Sines*, as in this *Question* it doth 20 *Degrees* 23 *Minutes*, and that is the true *Amplitude* required.

Secondly, Suppose you was about the *Cape* of *Virginia*, in *Latitude* 37 *Degrees* and 30 *Min.* and *Declination* 10 *Deg.* If you work as before-directed, you may find the true *Amplitude* to be 12 *Deg.* and about 36 *Min.* You may estimate the *Min.* but you cannot Steer by a whole *Deg.* when you have rectified your *Compass* by this; therefore this is sufficient for that Use, to shew you the difference between the true *Compass* and the Steering *Compass*, if you observe his *Rising* and *Setting* by it.

Note, The *Amplitude* is the distance of *Rising* or *Setting* of the *Sun* or *Stars* from the true *East* and *West Points* upon the *Horizon*.

As for the foregoing *Work*,——In the *Latitude* of 13 *Deg.* the *Sun* or *Star* having *North-Declination* 20 *Deg.* therefore they will rise 20 *Deg.* 33 *Min.* to the *Northward* of the *East*, and set 20 *Deg.* 33 *Min.* to the *Northward* of the *West*. But if the *Declination* had been 20 *Deg. South*, then they would have risen 20 *Deg.* 33 *Min. Southward* of the *East*, and set 20 *Deg.* 33 *Min.* to the *Southward* of the *West*.

And so if you bring these *Degrees* and *Minutes* into *Points* and *Quarters*, and use the *Variation-Compass* upon the *Instrument* of the *Moon* in the First Book, you may readily rectifie the *Compass* you Steer by.

SECT. V.

The Use of the Quadrant *and* Variation-Compass *in the First Book, on the* Instrument *of the* Moon *for shifting of* Tydes.

This *Instrument* contains two Parts or *Rundles*, which are the two uppermost in the aforesaid *Instrument* made of *Wood* or *Brass*, moving one upon the other, as there you may see. The biggest of the two uppermost *Rundles* represents the *Compass* you Steer the *Ship* by, which is subject to Variation: but the upper *Compass* doth represent the true *Compass* that never varieth, whereby you have a most necessary *Instrument* to rectifie the *Compass*, as Mr. *Wakely* hath made *Tables* to be used with it; but this will serve for use as near by the *Quadrant*.

Admit I am in the *Latitude* of 27 *Deg.* and *Declination* 20 *Deg. Northward*, and I observe the *Sun's Rising* and *Setting* to be due *East* and by *North*, and *West by South Point* of my Steering or *Variation-Compass*; the *Variation* in that *Latitude* is required.

The *Sun* having *North-Declination*, and in that *Latitude* of 27 *Deg.* if there be no Variation the *Sun* will rise (as you may presently find his *Amplitude* by the *Quadrant* and *Index*, 22 *Deg.* 34 *Min.* which is but 4 *Min.* not to be taken notice of, above) *E. N. E.* and sets *W. N. W.* But according to the foregoing *Propositions*, the *Sun* did rise at *E. b. N.* and set at *W. b. N.* Therefore it plainly appeareth that there is a full *Point* Variation. 11 d. 15 m. each Point.

Therefore on the *Variation-Compass* on the *Instrument* of the *Moon*, you must always bring the true *Point* of *Rising* and *Setting* on the upper *Compass*, to touch the false *Point* or *Rising* and *Setting*, found by Observation and *Steering-Compass*, on the

middle *Rundle*, being ſet in this Poſition. You will find the *E. b. N.* to be the true *E. N. E.* and the *W. and by N.* to be the true *W. N. W.* and the *N. b. E.* to be the true *N.* and the *S. b. E.* to be the true *S.* and the *S. E.* ¼ *Point Southerly*, to be the true *S. E. b. S.* ¼ *Southerly*; and the *South* ¼ *East*, to be the *South* ¼ *Weſt*: And ſo you may do with eaſe in all other *Obſervations*, in like manner as you have been ſhewn, by *Points*, *Halfs*, and *Quarters*, which is on the two *Trundles*; and be ſure nearer than ¼ of a *Point* I never did ſee any man Steer or ſheape a Courſe.

SECT. VI.

To know the Variation *by the* Quadrant.

You may do the ſame thing by the *Quadrant*, without the help of the *Rectifier* before ſpoken of, if you will remember, That this *Quadrant* hath eight *Points*, or ⅛ of the whole *Compaſs*, by which you may orderly reckon the whole, and ſet the *Index* to the greateſt difference either from the *Eaſt*, *Southward*, or *Northward*, or *Weſt*. In like manner as in the foregoing *Propoſition*, the true *Amplitude* of *Riſing* and *Setting* was 2 *Points*, or 22 *Deg.* 34 *Min. E. N. E.* Set the *Index* to the *Degrees* and *Points*, reckoning the *Deg.* from D on the *Arch* of the *Quadrant*, toward E the *Scale* of *Leagues* of the *Index*; then reckon the *Point* and *Degree* taken by Obſervation, which is 11 *Deg.* and 15 *Min.* a juſt *Point* of the *Compaſs*: therefore it being but *E. by N.* ſhort a *Point* of the true *Amplitude*, therefore the *E. b. N.* of the *Steering-Compaſs*, reſpecteth the true *E. N. E.* and the *N. b. E.* reſpecteth the true *N.* and ſo account all round the *Compaſs* a *Point* more than the *Steering-Compaſs* ſheweth: And if you would know which way the *Variation* is, you ſee it is a *Point* more from the *E.* than your *Compaſs* ſheweth *Northerly*.

But if the *Steering* or *Azimuth-Compaſs*, had ſhewn a *Point* more than the true *Amplitude* found by the *Quadrant* and true *Point*, the *Variation* had been *Weſterly*.

But ſuppoſe the *Amplitude* found had been a *Point Southerly*, *E. b. S.* and the *Sun's Riſing* and *Setting* had been a *Point Northerly*; by Obſervation of the *Ship-Compaſs*, you ſee there is two *Points* difference: therefore ſet the *Index* to two *Points*, from M the *Eaſt* or *Weſt* ſide of the *Quadrant*, as in this *Propoſition* you muſt reckon it, and you may ſee plainly that the *Eaſt Point* by the *Steering-Compaſs* is the true *Eaſt-South-Eaſt Point*; and the *South Point* is the true *South-South-Weſt Point*; and the *North* is the true *North-North-Weſt Point*; and ſo of all the reſt: And the *Variation* is *Southerly*. So that you ſee how readily this *Quadrant* doth theſe things, when the *Points* of the *Compaſs* is imprinted in a Mans mind, which muſt be, and is in all *Maſters* and *Mates*.

Suppoſe I would know by the *Quadrant* the true *Point* of the *Compaſs*, when *Bootes Arcturus* riſeth and ſetteth: In the *Latitude* of 40 *Deg. Bootes Arcturus* Declination is 20 *Deg.* 58 *Min.*

Set the Side of the *Index* and *Sine* to the *Latitude* of 40, and count the *Declination* 21 *Degrees* almoſt, from M on the *Arch*; and run your Eye up the *Parallel*, and it will cut the *Index* about 27 *Deg.* 50 *Min.* which is reduced into *Points* and *Quarters* by allowing *Gr.* 15 *Min.* to a *Point*, his Riſing will be almoſt *E. N. E.* ¼ a *Point Northerly*, his Setting *W. N. W.* ¼ *Weſterly*. But if the *Declination* of a *Star* of the *South* ſide the *Æquinoctial*, the Riſing had been *E. S. E.* ¼ *Southerly*, and his Setting *W. S. W.* ¼ *Southerly*.

In the like manner you may know the Riſing and Setting of any *Star* in an inſtant, by this *Quadrant* and *Index*, which I hold to be as neceſſary an *Inſtrument* as *Seamen* can uſe, in reſpect of its plainneſs, and brevity, and portability, ſo made as you ſee the *Figure*, the larger the better; And on it you may work all manner of *Traviſes* to the diſtance of 60 *Leagues* or *Miles* which is on the ſide of the *Index*. It being ſo plain and eaſie, I need not write any thing thereof; but for the *Learner's* ſake, take theſe few *Rules* following.

SECT.

SECT. VII.

To finde the Number of Miles *anſwering to one* Degree *of* Longitude, *in each ſeveral* Degree *of* Latitude.

In Sailing by the *Compaſs*, the Courſe ſometimes holds upon a great *Circle*, ſometime upon a *Parallel* to the *Æquator*, but moſt commonly upon a crooked *Line*, winding towards one of the *Poles*, which *Lines* are well known by the Name of *Rhombs*.

If the Courſe hold upon a great *Circle*, it is either *North* or *South* under ſome *Meridian*; or *Eaſt* or *Weſt* under the *Æquator*.

Deg.	Min.	Miles.
00	00	60
18	12	57
25	15	54
31	48	51
36	52	48
41	25	45
45	34	42
49	28	39
53	08	36
56	38	33
60	00	30
63	01	27
66	25	24
69	30	21
72	32	18
75	21	15
78	28	12
81	23	09
84	15	06
87	08	03

In theſe Caſes every *Degree* requires an allowance of 60 *Miles*, or 20 *Leagues*; every 60 *Miles* or 20 *Leagues* will make a *Degree* difference in the Sailing; therefore as was ſhewn in the firſt *Diagram*, and uſe of the *Line* of *Sines*, may be ſufficient here, which is the *Rule* of *Proportion*.

But if the Courſe hold *Eaſt* or *Weſt*, on any of the *Parallels* to the *Æquator*,

As the Radius *is to* 60 Miles, *or* 20 Leagues, *the Meaſure of one* Degree *of the* Æquator:
So is the Sine-Compl. *of the* Latitude, *to the Meaſure of* Miles *or* Leagues *to one* Degree *in that* Latitude.

But if you would know by the foregoing *Quadrant* the *Miles* anſwering to a *Degree* in each *Parallel* of *Latitude*, it is thus.

Set the *Ear* E on the *Center-Pin*, and reckon the *Degrees* of *Latitude* from D: to which ſet the Edge of the *Index*, and note the *Parallel-Line* that is at the *Degree*; carry your Eye on it to the Side C D, and from the *Center* to that *Line* you have the Number of *Miles* anſwering a *Degree* in that *Latitude*.

EXAMPLE.

In the *Latitude* of 18 *degrees* 12 *min.* ſet the *Index* 18 *gr.* 12 *min.* from D, and the *Parallel-Line* riſing with that *Degree*, with your Eye or a Pin follow to the Edge, and you will find it to be 57 *Miles*, the *Miles* anſwering one *Degree* of *Longitude* and 51 *Miles*, in the *Latitude* of 31 *gr.* 48 *min.* as in the foregoing *Table*; and ſo work for any other *Latitude* in like manner.

But if the Courſe hold upon any of the *Rhombs* between the *Parallel* of the *Æquator* and the *Meridian*, we are to conſider beſides the *Æquator* of the World to which we Land, which muſt be always known.

Firſt, The difference of *Longitude*, at leaſt in general.

2. The difference of *Latitude*, and that in particular.

3. The *Rhomb* whereon the *Courſe* holds.

4. The diſtance upon the *Rhomb*, which is the diſtance we are here to conſider, and is always ſomewhat greater than the like diſtance upon a great *Circle*. The firſt follows in the next *Propoſition*.

I. *To*

I. *To find how many* Leagues *do anſwer to one* Degree *of* Latitude, *in every ſeveral* Rhomb.

In this *Table* is the *Degrees* of every quarter *Point*, ½, and whole *Point* in the *Quadrant*; as the firſt quarter is 2 *gr.* 49 *m.* ſo the half *Rhomb* is 5 *gr.* 37 *m.* the third is 8 *gr.* 26 *m.* and the firſt *Point* from the *Meridian* is 11 *gr.* 15 *m.* and ſo you may plainly ſee the reſt.

As the Sine-Complement *of the* Rhomb *from the* Meridian, *is to* 20 Leagues *or* 60 Miles, *the Meaſure of* 1 Degree *at the* Meridian:
So is the Radius *or* Sine *of* 90, *to the* Leagues *or* Miles *anſwering to one* Degree *upon the* Rhomb.

Rhombs.	*Inclination to the Meridian*		*Number of Leagues.*	
	Gr.	*Min.*	*Leag.*	*par.*
	2	49	20	2
	5	37	20	10
	8	26	22	22
1	11	15	20	39
	14	4	20	62
	16	52	20	90
	19	41	21	24
2	22	30	21	65
	25	19	22	12
	28	7	22	68
	30	56	23	32
3	33	45	24	05
	36	34	24	90
	39	22	25	87
	42	11	26	99
4	45	00	28	08
	47	49	29	78
	50	37	31	52
	53	26	33	57
5	56	15	36	00
	52	4	38	90
	61	5	42	43
	64	41	36	76
6	67	30	52	26
	70	19	59	37
	73	7	68	90
	75	56	82	31
7	78	45	102	52
	81	34	136	30
	84	22	205	14
	87	11	407	60
8	90	00	*ad infinit.*	

Suppoſe by the *Quadrant* it were required to anſwer this *Queſtion*,

Sailing N. N. E. *from* 40 Degrees *of* North-Latitude, *How many* Leagues *ſhall the* Ship *run before it can come to* 41? *By reaſon this is the ſecond* Rhomb *from the* Meridian, *and the* Inclination *thereof is* 22 deg. 30 m.

Therefore ſet the ſide of the *Index* E L to the ſecond *Point* from the *Meridian N. N. E.* 22 *d.* 30 *m.* and reckon from C 20 *Leagues* towards D, and with your Eye or a Pin follow the *Parallel-Line* to the *Index*, and you will find it cut 21 *Leagues* 65 *parts* (or better than ½ more) the number of *Leagues* you muſt Sail before you can reach 1 *Degree*.

You may do the ſame by the *Travis-Scale* thus. Extend the *Compaſſes* from 2 *Points* neareſt the end of the *Scale*, and greateſt *Number* of the *Line* of *Numbers* that is *N. N. E.* 2, and *E. N. E.* 6 *Points*, unto 20 *Leagues* on the *Line* of *Numbers*; remove the *Compaſſes* to 100 in the *Line* of *Numbers*, and the other *Point* of the *Compaſs* will reach to 21 *Leagues* $\frac{6}{10}$ or 65 *parts*, as before in the *Line* of *Numbers*.

This may be found alſo by a *Line* of *Chords* and *Equal Parts*, if you draw a *Right Line*, and take with your *Compaſſes* 20 *parts*, and lay it from one end on the *Line*; then take 60 *deg.* and ſweep an *Arch*, and take 2 *Points* with your *Compaſſes*, and lay from the *Meridian* on that *Arch* from *N. N. E.* and draw the *Secant* or *Rhomb-Line*, at 20 *Leagues* draw a *Perpendicular* or *Line* at *Right Angles* there to the former, and meaſure the diſtance from the *Center*, to the Interſection of the *Line* drawn from 20, with the *Rhomb-Line* on the *Scale* of *Leagues* or *Equal Parts*, and you will find it the ſame as before. And ſo the *Quadrant* ſhews you all at one ſight, if you underſtand without more words. By the *Artificial Sine* and *Number*, Extend your *Compaſſes* from the *Sine* of the *Rhomb* 67 *deg.* 30 to 20 in the *Line* of *Numbers*, the ſame Extent will reach from 8 *Points*, or 90 *deg.* or 100 in the *Line* of *Numbers*, to 21 *Leagues* 65 *parts*, as before. This conſider in general; I ſhall ſhew you more particularly in 12 *Proofs* (how of theſe four, any two being given, the other two may be found, both by *Mercator's Chart*, and all other ways, as is uſual) when I come to treat more particularly of *Navigation*.

II. *By*

II. *By one* Latitude, Rhomb, *and* Diſtance, *To find the difference of* Latitudes.

Let the place given be C in the *Latitude* of 40 *Degrees*, that is in the *Center* of the *Quadrant*, the ſecond *Latitude* unknown; The diſtance upon the *Rhomb* 21 *Leagues* 65 *parts* of a *League*; the *Rhomb N. N. E.* the ſecond from the *Meridian*: Therefore ſet the *Index* to the *Point*, and count 21 *Leagues* 10 *parts*, and run your Eye up the *Parallel-Line* you there meet with, and reckon the *Leagues* from the *Center* C to that *Line*, and you will find it 20 *Leagues*; and ſuch is the difference of *Latitude* required.

It is eaſie to be underſtood how to lay it down by the *Plain Scale*; therefore I ſhall forbear to write any more of that Way.

As the Radius, *to the* Co-ſine *of the* Rhomb *from the* Meridian:
So the diſtance upon the Rhomb, *to the difference of the* Latitudes.

Extend the *Compaſſes* from the *Sine* of 90, to the *Co-ſine* of the *Rhomb* 67 *deg.* 30 *m.* the ſame diſtance will reach from 21——65 *Leagues* in the *Line* of *Numbers*, to the difference of *Latitude* 20 *Leagues*. In like manner you muſt work for all ſuch *Propoſitions*, let the *Number* be greater or leſs, by either *Inſtrument*.

The *Travis-Scale* is the ſame manner of Work, as the *Artificial Sines*, *Tangents*, and *Numbers*; For extend the *Compaſſes* from 8 *Points* to 2 *Points*, the ſame diſtance will reach from 21: 65 in the *Line* of *Numbers*, to 20 the difference required.

III. *By the* Rhomb *and both* Latitudes, *To find the Diſtance upon the* Rhomb.

As ſuppoſe the one place given were C the *Center* of the *Quadrant*, in the *Latitude* 40 *deg.* the ſecond place in the *Latitude* 41 *deg.* and the Courſe the ſecond from the *Meridian*.

Set the *Index* to the *Rhomb*, and account 20 *Leagues*, which is 41 *deg.* the ſecond *Latitude*, and carry your Eye on that *Parallel* that leads to the *Index*; and there it will cut the diſtance upon the *Rhomb*, which in this *Queſtion* is 21 *Leagues* 65 *parts*.

Extend the *Compaſſes* from the *Co-ſine* of the *Rhomb* from the *Meridian*, to the *Radius* or *Sine* of 90——

The ſame Extent will reach from 20 *Leagues*, the difference of *Latitude*, to 21: 65 in the *Line* of *Numbers*, the diſtance upon the Courſe required.

IV. *By the diſtance and both* Latitudes, *To find the* Rhomb.

Suppoſe the Place given was at C, in *Latitude* 40 *deg.* and the ſecond Place a *Degree* or 20 *Leagues* further *Northward*, and the diſtance was 21——65 *Leagues* upon the Courſe.

From the *Center* C reckon 20 *Leagues* towards D, follow that *Parallel*, and ſet the *Index*, and count the diſtance until it touch the *Parallel*, and look in *Arch* of the *Quadrant*, and you will find the *Rhomb* 22 *gr.* 30 *m.* or *N. N. E.* 2 *Points* from the *Meridian*.—— Or, Extend the *Compaſſes* from the diſtance upon the *Rhomb* 21: 65, to the diſtance of *Latitudes* 20 *Leagues*; The ſame Extent will reach from the *Radius* or *Sine* of 90, to the *Sine-Complement* of the *Rhomb* 67 *deg.* 30, which was required.

V. *By the difference of* Meridians, *and* Latitude *of both Places*, *To find the* Rhomb.

As if the Place given was C the *Center* of the *Quadrant*, 40 *deg.* and 20 *Leagues* was the difference of *Latitude Northward*, that is 41 *deg.* and the difference of *Longitude* 8 *Leagues* 45 *parts* of a *League*.

Firſt, count from C the difference of *Latitude* 20 *Leagues*, on that *Parallel* count 8 *Leagues* 45 *parts*; to that put the *Index*; and in the *Arch* you will find the *Courſe* 22 *gr.* 30. from the *Meridian*.

Extend the *Compaſſes* from 20 *Leagues* to 8: 45, the ſame Extent will reach from 90 to the *Tangent* of the *Rhomb* 22 *gr.* 30 *min.* as before.

VI. *By the* Rhomb *and both* Latitudes, *To find the difference of* Longitude, *or departure from the* Meridian.

Let the *Rhomb* be 2 *Points* from the *Meridian*, the one *Latitude* given 40 *deg.* the other *Latitude* 41 *deg.* the difference 20 *Leagues*.

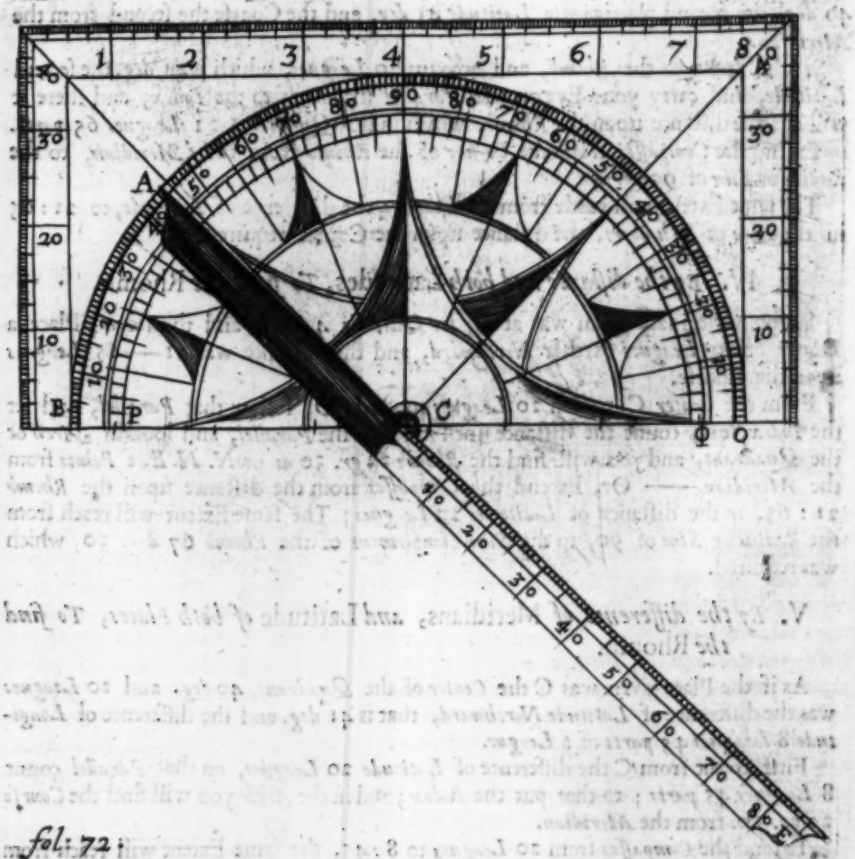
Set the *Index* to the *Point* and *Rhomb* 20 *gr.* from the *Meridian*, and count 20 *Leagues* the difference; on that *Parallel* reckon the *Leagues* between the *Side* and the *Index*, and you will find it in this *Queſtion* 8 *Leagues* 45 *parts*, the *Meridians-diſtance* required. —— Or, Extend the *Compaſſes* from the *Tangent* of the *Rhomb* 22 *gr.* 30, to *Radius* 90, the ſame Extent will reach from the difference of *Latitude* 20 *Leagues*, to the departure from the *Meridian* 8 *Leagues* 45 *parts*.

Theſe ſix laſt *Propoſitions* depend one upon the other, as you may plainly ſee; which may be ſufficient for the Explanation of the *Quadrant*, by which may be underſtood much more.

Chap. VII.

How to make a moſt Uſeful Protractor.

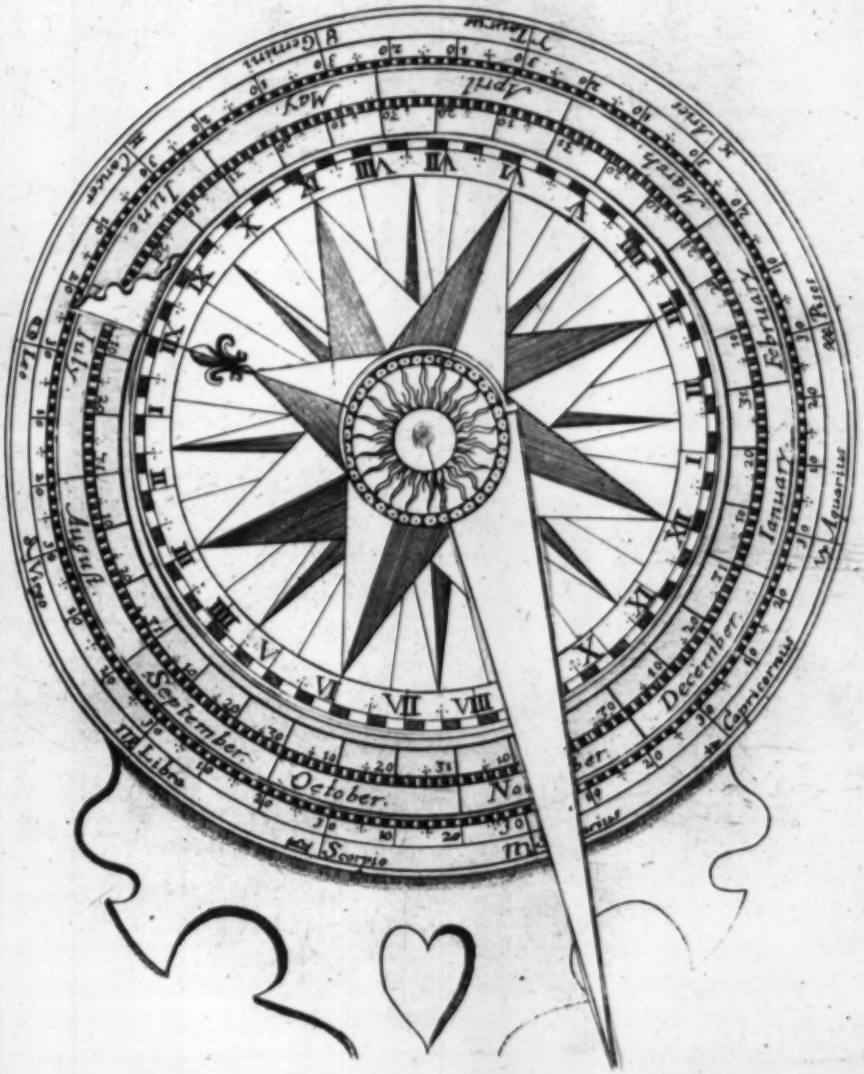
This *Inſtrument* is always to be made in *Braſs* or *Copper*, but beſt in *Braſs*. On the *Center* C draw the *Semicircle* B O, and divide it into two 90, or 180 *Degrees*, as you may ſee the *Figure*; and let the ſixteen *Points* of the *Compaſs* P P be ſet in the inward *Circle*, with the *Quarter-Points*. And let the



fol. 72.

Index

A Nocturnal


April
May
June
July
August
September
October
November
December
January
February
March
Aries
Taurus
Gemini
Cancer
Leo
Virgo
Libra
Scorpio
Sagittarius
Capricornus
Aquarius
Pisces

Index A E be two *Diameters* and ½ long, and ſo fitted as the *Semidiameter* of the *Circle* may be the diſtance from the *Center*, for the ready ſetting to any number of *Degrees*, or *Points* and *Quarters* the Edge thereof, and divide from the *Center* to the end of the *Index* into 100 equal Parts, which are accounted ſometime *Leagues*, and reckoned by the *Surveyors* of *Land Perches*, or any other Denomination of *Numbers*: You may call it for protraction according as you have occaſion to uſe it.

Let the *Index* be faſtned to the *Center* with a *Braſs Rivet*, and through the midſt of the *Rivet* there muſt be a *Hole* drill'd; you muſt put the *Pin* or *Needle* ſpoken of in the laſt *Chapter*, upon any *Point* aſſigned, in any *Chart* or *Protraction* whatſoever. You may divide the Edges into equal parts, by which you may make a *Meridian-Line* on the blank *Charts*, according to *Mercator's* or *Wright's* Projection.

And now you have a neceſſary *Inſtrument*, which will protract any *Travis* or piece of *Land* upon *Paper*, with as much ſpeed as any *Inſtrument* I ever yet knew, and readier by much, the uſe whereof ſhall be ſhewn in this *Treatiſe*.

CHAP. VIII.

The Projection *of the* Nocturnal.

IT conſiſts, as you ſee, of three Parts. The greateſt or handle-part hath on it two *Circles* divided: On the firſt or outmoſt is the *Ecliptick*, divided into 12 equal Parts, in which is put the 12 *Signes*; and each of thoſe 12 Parts is divided into 30 equal Parts or *Degrees*, in each *Signe*, numbered 10, 20, 30, as you ſee the *Figure* plainly ſheweth. The inward *Circle* is the 12 *Months* of the *Year*, ſet in by a *Table* of the *Sun's* place every day of the *Year*, accounting the *Degrees* of the outward *Circle*, and the number of *Days* in each *Month* equally divided and ſet down 10, 20, 30.

Note, Where to begin to divide the *Months* and *Days* is thus. Obſerve the brighteſt *Guarde*, or by *Calculation* or the *Globes* find when he comes to the *Meridian* juſt at 12 a Clock at Night. In the following *Tables* the *Right Aſcenſion* of the brighteſt *Guard* is 223 *Degrees* 31 *Minutes*; from it ſubſtract 12 *Hours*, or 180 *Degrees*, the Remainder is 43 *deg.* 31 *min.* the *Right Aſcenſion* of the *Sun* the 26th day of *April*, in 16 *deg.* of *Taurus*, which muſt be uppermoſt next the *Zenith* in the middle.

The other Part or middle *Rundle* equally divideth the outward *Circle* into twice 12 *Hours*; and within that is a *Circle* equally divided into 32 Parts, or *Points* of the *Mariner's Compaſs* projected thereon. The upper part is an *Index*, the length is from the *Center* to the Foot of the *Inſtrument*; all three being faſtned with a piece of *Braſs*, ſo Rivetted that the *Center* is an Hole through which you may ſee the *North-Star*. You may make it in *Braſs*, or good dry *Box*.

The Uſe of the Nocturnal.

THE Uſe of the *Nocturnal* is eaſie and ready. Let the *Tooth* or *Index* of the middle *Circle* be ſet to the *Day* of the *Month*, and it will cut in the outward *Circle* the *Sun's* Place in the *Ecliptique*. Then hold the *Inſtrument* on high, a pretty diſtance from you, with the Foot A B right with the *Horizon* level: Then look through the Hole of the *Center*, and ſee the *North-Star*, turning the long *Index* or *Pointer* upwards or downwards, untill you ſee the brighteſt of the *Guards* over or under the Edge that comes ſtraight to the *Center*. Then look on the *Hour-Circle* by the Edge of the *Pointer*, and it ſhews the *Hour* of the *Night*, and likewiſe the *Point* of the *Compaſs* the *Guard* beareth from the *Pole*; by the which you may have his *Declination* by the following *Tables* exactly.

The *Hour* of the *Night* may be alſo found by the *Right Aſcenſion* of the *Sun* and *Stars*. Thus, When that you ſee any *Stars* in the *South*, whoſe *Right Aſcenſion* is known, and alſo the *Right Aſcenſion* of the *Sun* for that day, you ſhall ſubſtract the *Sun's Aſcenſion* from the *Star's*; that which remaineth divide by 15, to bring it into

Here place the North Nocturnal for the Pole Star and Guards

Hours; for 15 *Degrees* makes an *Hour*, and 4 *Minutes* make a *Degree*; thereby you have the *Hour* of the *Night*. If the *Sun's Aſcenſion* be more than the *Star's*, in ſuch caſe you ſhall add 360 *Degrees* to the *Aſcenſion* of the *Stars*, and then ſubſtract the *Sun's Aſcenſion*, as before directed, you have the time alſo.

Chap. IX.

How to uſe the Pole-Star's Declination *and* Table, *and thereby to get the* Latitude.

The *Pole-Star*, being ſo very well known to all *Sea-men*, is therefore made the moſt uſe of by them: Therefore know, That this *Table* is made for the year 1660. the true *Declination* being 2 *deg.* 30 *min.* but will ſerve for many years after. This *Table* is made contrary to the two former *Tables*; for whereas the *North Point* of the *Nocturnal* is the firſt *Point* you reckon from, and was on the former *Nocturnal* reckoned from *South*: ſo of this *Nocturnal* you muſt take the *Point* at the *Tooth* for *North*, and ſo reckon forward *North and by Eaſt*, and ſo on to *Eaſt* and *South-Eaſt*, *South* and *Weſt*, to *North* again.

And likewiſe in the *Table*, you muſt begin in like manner at that part of the *Table* that lies directly under the *Pole*; which, as before-ſaid, is properly called the *North*, and ſo proceed about the *Pole*, aſcending from this loweſt or *North Point* of the *Meridian*, as was ſaid before, to the *North-Eaſt*, *Eaſt*, and *South-Eaſt*, ſo to the *South* or higheſt *Point* of aſcending, being directly over the *Pole*: From the *South* they deſcend again by the *Weſt*, and ſo return to the *North* again.

Obſerve this, That the brighteſt of the *Guards* is the firſt of the little *Bear*, which is the *Star* you are to obſerve, and is almoſt in oppoſition to the *Pole-Star*.

Note, That when the *Guard-Star* is under the *Pole*, then the *Pole-Star* is above the *Pole*; and when the *Guard-Star* is above the *Pole*, then the *Pole-Star* is under the *Pole* ſo many *Degrees* and *Minutes* as the *Table* ſhews you.

The Uſe of this *Table* and *Inſtrument* is this: Look with the *Nocturnal*, and ſee what *Point* the *Guards* bears from the *Pole*, as before-directed; and if you find the *Guard* is not on a full *Point*, ſtay a little longer until he is juſt, and then obſerve the height of the *Pole-Star* exactly as you can; then knowing by your *Dead Reckoning* within a *Degree* or two what *Latitude* you are in, look for the neareſt to that *Latitude* in the top of the *Table*; and if you find the *Point* of the *Compaſs* which the *Guard-Star* is upon, in the firſt *Column* of the *Table*, and in that *Line* under the *Column* of your *Latitude*, you ſhall find the number of *Degrees* and *Minutes* the *Pole-Star* is either above or below the *Pole*, according to the direction of the laſt *Column* of the *Table*, which you muſt thus make uſe of; If the *Star* be any thing above the *Pole*, ſubſtract the *Number* in the *Table* from the height of the *Star* obſerved: but if the *Star* be under the *Pole*, then add the *Number* found in the *Table* to the height obſerved, by which you ſhall have the height of the *Pole*.

For Example. Eſtimate the *Latitude* to be near 40 *Degrees*, and obſerve the *Pole-Star*. Suppoſe you find the *Altitude* 40 *Degrees*, and the *Guard-Star* bears *N. N. E.* from the *Pole*; therefore look for *N. N. E.* in the firſt *Column*, and right under your eſtimated *Latitude* 40, in the ſame *Line* with *N. N. E.* you will find the *Declination* to be 1 *Degree* 30 *Minutes*; ſubſtract that from 40 *Deg.* the *Altitude* obſerved leaves the true *Latitude* 38 *Degrees* 30 *Minutes*. But if the *Guard-Star* had been *S. S. W.* then the *Pole-Star* had been under the *Pole*; which being added to the *Altitude* obſerved the *Latitude* would have been exactly 41 *Degrees* 30 *Minutes* by the *Star*. So the *Star's Altitude* by obſervation being 55 *Deg.* the *Guard* bears from the *Pole-Star S. E. b. S.* the *Declination* againſt that *Point* is 2 *Degrees* 30 *Minutes*, added to 55. had been 57 *Degrees* 30 *Minutes* for the *Latitude*: but if your eſtimated *Latitude* had been near 50, and the *Guard* bear from the *Pole North-Weſt*

	d.	m.
40 *Deg.*	40	00
1 *Degree* 33 *Minutes*	01	30
	38	30

West by North, the *Declination* againſt that *Point* is 2 *deg.* 30 *min.* ſubſtracted from 55 *Degrees*, the *Altitude* obſerved, there remains 52 *deg.* 30 *min.* the *Latitude* of the place by the *Star*.

A Table *of the* North-Star's Declination *in theſe ſeveral* Latitudes.

	The True Point of the Compaſs.	0		20		30		40		50		60		70		
		D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M	D.	M	
If the former of the Guards be aſcending from the North *or lower part of the* Meridian.	North.	2	10	2	10	2	10	2	09	2	09	2	08	2	07	*Above the* Pole.
	N. b. E.	1	53	1	53	1	53	1	52	1	52	1	51	1	49	
	N. N. E.	1	31	1	31	1	30	1	30	1	29	1	28	1	25	
	N.E.b.N.	1	06	1	05	1	04	1	03	1	02	1	01	0	58	
	N. E.	0	39	0	38	0	37	0	36	0	35	0	33	0	30	
	N. E. b. E.	0	10	0	09	0	08	0	07	0	06	0	04	0	01	
	E. N. E.	0	18	0	19	0	20	0	21	0	22	0	23	0	26	*Under the* Pole.
	E. b. N.	0	49	0	50	0	50	0	51	0	52	0	53	0	56	
	East.	1	15	1	15	1	16	1	17	1	18	1	19	1	21	
	E. b. S.	1	38	1	39	1	39	1	40	1	41	1	42	1	44	
	E. S. E.	2	00	2	00	2	00	2	00	2	00	2	01	2	02	
	S. E. b. E.	2	15	2	15	2	15	2	15	2	16	2	16	2	16	
	S. E.	2	25	2	25	2	25	2	25	2	25	2	25	2	25	
	S. E. b. S.	2	30	2	30	2	30	2	30	2	30	2	30	2	39	
	S. S. E.	2	29	2	29	2	29	2	29	2	29	2	29	2	29	
	S. b. E.	2	22	2	22	2	22	2	22	2	22	2	22	2	22	
If the former of the Guards be deſcending from the South *or upper part of the* Meridian.	South.	2	10	2	10	2	10	2	11	2	11	2	11	2	12	
	S. b. W.	1	58	1	53	1	54	1	53	1	55	1	55	1	57	
	S. S. W.	1	31	1	32	1	32	1	33	1	34	1	35	1	38	
	S. W. b. S.	1	07	1	07	1	08	1	10	1	11	1	13	1	13	
	S. W.	0	39	0	40	0	41	0	40	0	43	0	44	0	47	
	S.W. b. W.	0	10	0	11	0	12	0	13	0	14	0	16	0	19	
	W. S. W.	0	19	0	19	0	17	0	16	0	15	0	13	0	10	*Above the* Pole.
	W. b. S.	0	48	0	47	0	46	0	45	0	44	0	43	0	42	
	West.	1	15	1	14	1	13	1	12	1	11	1	10	1	08	
	W. b. N.	1	39	1	39	1	38	1	37	1	36	1	35	1	33	
	W. N. W.	2	00	1	59	1	59	1	58	1	58	1	57	1	56	
	N.W.b.W.	2	15	2	15	2	14	2	14	2	14	2	13	2	12	
	N. W.	2	25	2	25	2	25	2	25	2	24	2	24	2	24	
	N.W. b. N.	2	30	2	30	2	30	2	30	2	30	2	30	2	30	
	N. N. W.	2	29	2	29	2	29	2	29	2	29	2	29	2	29	
	N. b. W.	2	22	2	22	2	22	2	22	2	22	2	21	2	21	

I hope the young *Seamen* are pleaſed for *Examples*, it being made ſo plain to their Capacity, and as profitable for their Uſe as any *Rule* whatſoever.

CHAP. X.

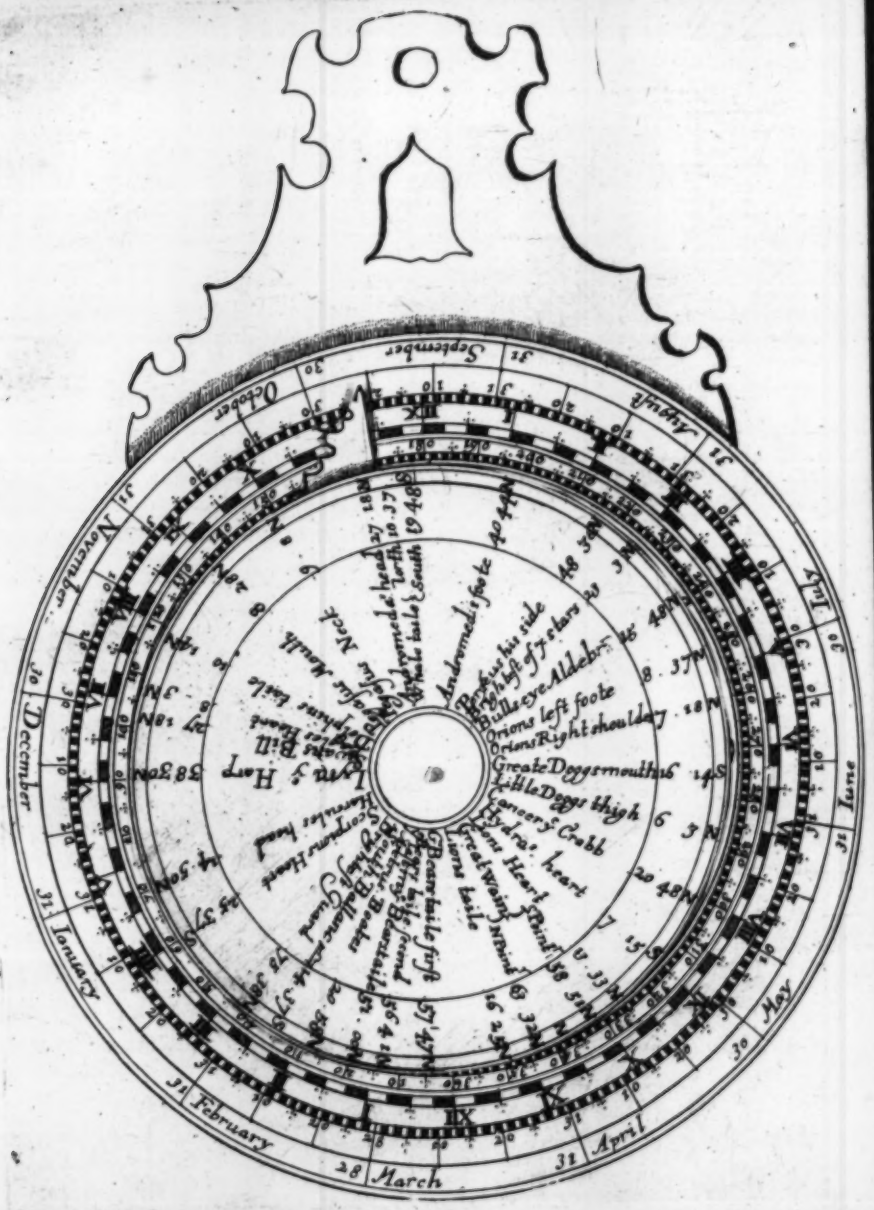
How to make a most Useful Instrument *of the* Stars, *and by it to know most readily when any of* 31 *of the most notable* Stars *will come to the* Meridian, *what* Hour *of the* Night, *at any time of the* Year, *at the first sight.*

THis *Instrument* consisteth of two parts, which is two *Rundles*; on the back side of the foregoing *Nocturnal* it may be very fitly made: On the matter or greater *Rundle* are three *Circles* divided; the outermost is the 12 *Months* of the *Year*, begun the 10th of *March*, the day the *Sun* enters into *Aries*; and the *Days* equally divided to the Number of *Days* in each *Month*. The second *Circle* representeth the 24 *Hour Circle*, divided equally into 24 *Hours*, $\frac{1}{2}$ and $\frac{1}{4}$, beginning the 10th of *March* at 12 a Clock at *Noon*, the time the *Sun* comes to the *Meridian*, and the first *Degree* of *Aries*. The third and inward *Circle* is the *Æquinoctial*, divided into 360 *Degrees*; by them is accounted the *Right Ascension* of these 31 *Stars* in the *Table* following.

A Table *of the* Longitude, Latitude, Right Ascensions, *and* Declinations, *of* 31 *of the most Notable* Fixed Stars: *Calculated from* Tycho *his* Tables, *rectified for the Year of our Lord*, 1671.

	Longitude.	Latitude.	Ascension.	Declination.	Nor. Sou.	
The Whale's *Tail*	27 56 ♓	10 47 S	06 45	19 48	S	2
The Bright Star *in the* South *Foot of* Androm.	09 39 ♉	27 46 N	25 57	40 44	N	2
The Bright Star *in the Right Side of* Perseus.	27 17 ♉	30 05 N	44 16	48 36	N	2
The Bright Star *of the* 7 Stars *or* Pleiades.	24 24 ♉	04 0 N	52 00	23 03	N	3
The South *Eye of the* Bull Aldebaran.	05 12 ♊	05 31 S	64 17	15 48	N	1
The Bright Star *in the left Foot of* Orion Riges.	12 17 ♊	31 11 S	74 44	8 37	N	1
Orion's *right Shoulder towards the* East.	24 12 ♊	16 6 S	84 23	07 18	N	1
The glittering Star *in the Mouth of the great* Dog.	09 35½ ♋	39 30 S	97 42	16 14	S	1
The Little Dog's *Thigh* Procyon.	21 18½ ♋	15 57 S	110 34	06 03	N	2
In the South *Arm of the* Crab.	09 03½ ♌	05 08 S	125 22	20 48	N	3
The Bright Star *called the Heart of the* Hydra.	22 45 ♌	22 24 N	137 54	07 15	S	1
The Lion's *Heart* Regulus.	25 17 ♌	00 26 N	147 43	13 33	N	1
The lower of the Pointers.	14 43½ ♌	45 03 N	160 18	58 08	N	2
The White or North Pointer.	10 34 ♌	49 40 N	160 48	63 32	N	2
The Lion's *Tail.*	17 03 ♍	12 18 N	173 04	16 25	N	1
The First between the Tail and the Body.	04 10 ♍	54 18 N	189 03	57 47	N	2
The second of the Tail of the Horses.	10 56 ♍	56 14 N	197 37	56 41	N	2
The Fore-Horse, *or last in the Tail.*	22 12 ♍	54 25 N	203 37	51 00	N	2
In the Skirt of his Garment Arcturus.	19 39 ♎	31 2½ N	210 13	20 58	N	1
The South Balance *of* Libra.	10 31 ♏	00 26 N	218 13	14 37	S	2
The Brightest of the Guards.	08 16 ♌	72 51 N	223 37	75 38	N	2
The Scorpion *Heart* Antares.	08 13 ♐	04 27 S	242 23	25 37	S	1
Engonasis *Head* Hercules.	11 31 ♐	37 23 N	254 12	14 50	N	3
The Bright Star *of the* Harp Lyra.	10 43 ♑	61 47 N	276 27	38 30	N	1
The Swan's *Bill.*	26 44 ♑	49 02 N	289 23	27 18	N	3
The Bright Star *the* Eagle's *Heart.*	27 09 ♑	29 21½ N	293 41	08 03	N	2
The Dolphin's *Tail.*	09 32 ♒	29 08 N	304 24	10 14	N	2
The Mouth of Pegasus *the winged* Horse.	27 22 ♒	22 7½ N	322 03	08 24	N	3
The Bright Star *of* Pegasus *Neck.*	1 39½ ♓	17 41 N	336 21	09 08	N	3
The Southern Star *in the Wing of* Pegasus Macrobe	18 56½ ♓	19 26 N	342 07	13 28	N	2
Andromeda *her Head.*	09 47 ♈	25 42 N	357 54	27 18	N	2

On


September
October
November
December
January
February
March
April
May
June
July
August
Andromeda's foote
Perseus his side
Pleiades
Bulls eye Aldebr
Orions left foote
Orions Right shoulder
Great Dogs mouth
Little Dogs thigh
Cancers Crabb
Hydras heart
Lions Heart
Great Waine
Lions taile
Beares taile
Beares fist
Arcturus
Corona
Hercules head
Hercules Knee
Draco
Cepheus
Cassiopeia
Pegasus Mouth
Pegasus Neck
Pegasus Wing
Pegasus Knee
Pegasus Hoofe
Pegasus taile
Aquarius Urne
Aquarius Hand
Aquarius Head
Aquarius Breast
Aquarius Wing
Aquarius Knee
Aquarius Hoofe
Fishes Mouth
Fishes Head
Fishes Taile
Fishes Knee
Fishes Hoofe
Ram's Head
Ram's Taile
Ram's Knee
Ram's Hoofe
Pleiades
Hyades
Perseus Head
Perseus Knee
Perseus Hand
Perseus Sword
Perseus Heele
Charioteers Hand
Charioteers Heart
Charioteers Foote
Charioteers Knee
Charioteers Goate
Charioteers Shoulder
Charioteers Elbow
Charioteers Breast
Charioteers Wing
Charioteers Hoofe
Charioteers Taile
Lynx's Head
Lynx's Taile
Lynx's Hoofe
Lynx's Knee
Lynx's Breast
Lynx's Eare
Lynx's Mouth
Lynx's Eye
Lynx's Heart
Lynx's Foote
Lynx's Taile
Lynx's Knee
Lynx's Hoofe

On the other *Rundle* or upper part, is placed all theſe aforeſaid *Stars*; and any other you may ſet thereon, if you follow this *Rule*.

For *Example*, Firſt ſet the *Index* to the 10th day of *March* of the upper *Circle*; on the under *Circle*, which will be at 12 a Clock at *Noon*, or 360 *Degrees*, ſtop it faſt there, that it may not move, until you have placed the *Stars* on it as you intend to ſet thereon. As ſuppoſe you would ſet the *Whale's Tail* on the *Rundle* in his place; look in the foregoing *Table*, and you will find his *Right Aſcenſion* 6 *deg.* 45 *min.* account that from the 10th of *March*, and on the *Æquinoctial Circle*, and lay a *Ruler* from the *Center* over the 6 *deg.* 45 *min* in the Matter and *Æquator* or inward *Circle*, and draw the *Line* from the *Center* to the outward Edge of the upper *Circle*, and thereon ſet the *Name* of the *Star*, next to that the *Declination* of the *Star*, and the *Letter S* or *N.* repreſenting *South* or *North Declination*: on the inward *Circle*, ſet before each *Star* the *Magnitude* of the *Star*, whereby you may know the better, as the *Figure* following ſhews you all plain.

Take this *Example* more. Suppoſe you would ſet the *Lion's Heart* in his place; In the *Tables* I find his *Right Aſcenſion* is 147 *deg.* 43 *min.* reckon that *Number* on the *Æquinoctial Circle* next the *Rundle*, and draw the *Line* as before-directed, 1 ſignifying the *Firſt Magnitude*, ſecondly his *Name*, thirdly 13 *deg.* 33 *N*, for his *North Declination*.

The *Inſtrument* in this poſture, you will find the *Lion's Heart* will come to the *Meridian* at almoſt 10 a Clock in the Evening the 10th day of *March* in any *Latitude*.

How to know the Hour *of the* Night *any* Star *comes to the* Meridian *in any* Latitude.

YOu have been in a manner ſhewed it before in the laſt *Example*. Set the *Index* or *Hand* of the upper *Rundle* to the *Day* of the *Month*, and right againſt the *Star* is the *Hour* of the *Night*, in the Matter the *Star* will be on the *Meridian*.

For *Example*, Suppoſe you would know the *Hour* of the *Night* the *Bull's Eye* comes to the *Meridian* the 20th *Day* of *October*; Set the *Index* to the *Day*, and right againſt the *Bull's Eye* is ¾ of an *Hour* paſt 1, the time in the *Morning* that *Star* will be on the *Meridian South*. And in the ſame manner you may ſee the *Stars*, and *Hours* they come to the *Meridian* that *Night* and *Day*. For note the upper half of the *Circle*, and 12 *Hours* is the *Day-hours*, and the lower and Handle-half is the *Night-hours*. You begin to reckon the *Day-hours* on the left ſide of the *Inſtrument*, and the *Night-hours* on the right ſide; ſo round with the *Sun*.

How to know what Stars *are in Courſe at any time or* Day *of the* Year.

THe *Courſe* and ſeaſonable coming to the *Meridian* of the *Stars*, and what are fit to be obſerved, is ſhewn you at once, the *Inſtrument* in the former poſture, if you look againſt each *Star*, you have the *Hour* of the *Night* and *Day*, being the whole 24 *Hours*. This is ſo plain, you need no further *Precept*.

How to know the Hour *of the* Night, *by the* Stars *being on the* Meridian.

SUppoſe it were required to know the *Hour* of the *Night* the 10th of *December*, the brighteſt of the 7 *Stars* being on the *Meridian South*: Set the *Index* to the day of the *Month*, and right againſt the brighteſt of the 7 *Stars*, is half an *Hour* paſt 9 at *Night*, which is the *Hour* required.

CHAP.

Chap. XI.

Of the Croſiers.

When the *Mariners* paſs the *Æquinoctial Line* towards the *South*, ſo that they cannot ſee the *North-Star*, they make uſe of another *Star*, which is the *Conſtellation* called the *Centaur*; which *Star*, with three other notable *Stars* which are in the ſame *Conſtellation*, maketh the *Figure* of a *Croſs* (betwixt his *Legs*) for which cauſe they call it the *Croſiers*. And it is holden for certain, That when the *Star* A (which of all four cometh neareſt the *South-Pole*) is



North and *South* by the *Star* B, then it is rightly ſcituated to take the Height by: And becauſe this *Star* A, which is called the *Cocks-foot*, is 30 *Degrees* from the *South-Pole*, it cometh to paſs, it being ſcituated as before-ſaid, we take the Height thereof (which is then the greateſt that it can have) this Height will truly ſhew how far we are diſtant from the *Æquinoctial*: For if the ſaid Height be 30 *Degrees*, then we are under the very *Æquinoctial*: But if it be more than 30 *deg.* then are we by ſo much paſt the *Æquinoctial*, toward the *South*: And if it be leſs than 30 *deg.* ſo much as it wanteth, we are to the *North* of the *Æquinoctial*. And here it is to be noted, That when the *Guards* are to the *North-Eaſt*, then is the *Star* in the *Croſiers* fitly ſcituated for obſervation, becauſe then they are in the *Meridian*.

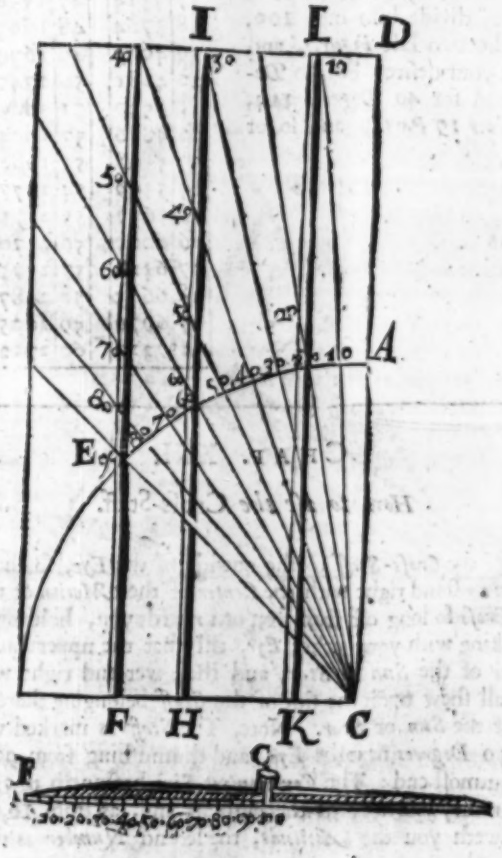
Chap. XII.

How to make the Croſs-Staff.

The *Mariner's Croſs-Staff* is that which by the *Aſtronomers* is called *Radius Aſtronomicus*, by which we obſerve the *Celeſtial Lights* above the *Horizon*. The *Mathematicians* have invented many kinds of *Inſtruments*, whereof the *Croſs-Staff* and *Quadrant* are the moſt uſeful above all the reſt. At *Sea* it is not every Mans Work to make and mark a *Croſs-Staff*, and other *Inſtruments*, for want of Practice needful thereunto; yet notwithſtanding it is fit and neceſſary that a *Maſter*, his *Mates*, and *Pilot*, who are to have the Uſe of it, ſhould at leaſt know when it is well made.

For to mark well a *Croſs-Staff*, you ſhall make a plain flat *Board* of good dry *Wood*,

Wood, fifteen or ſixteen *Inches* broad, and about four *Foot* or three *Foot* long: Paſte it well with good *Paper*; draw along the one Side a *Right Line*, as in the next following *Figure* C A D; out of the *Line* C draw a *Square Line* upon A C, as C B, and upon the *Center* C draw the *Arch* A E B, being a *Quadrant* or fourth part of a *Circle*; divide that into two parts; the one half thereof, as A E, divide into 90 Equal Parts or *Degrees*, thus; firſt into three Parts, and each of the ſame again into three; theſe Parts each into two, and each of the laſt Parts into five: ſo the *Arch* A E ſhall then be divided into 90 Parts. Then take a right *Ruler*, lay the one end on the *Point* or *Center* C, the other upon each *Point* of the foreſaid ſeveral *Diviſions*, and draw ſmall *Lines* out of C, through each of the foreſaid *Points* or *Degrees* of the *Quadrant*, ſo long as they can ſtand upon the *Board*, as you may ſee it plain in the *Figure*. Then take with a pair of *Compaſſes*, juſt the half length of the *Croſs* that you would mark the *Staff* after; prick it from the *Point* C towards B; as by *Example*, from C to F, and from D to G; joyn theſe two *Points* with a *Line* to one another; and even into ſuch Parts as that *Line* is cut, and divided by the aforeſaid *Lines* coming out of the *Center* of the *Quadrant*, muſt your *Staff* be marked, whether the *Croſs* be long or ſhort, as appeareth by the *Lines* H I and K L, which are drawn for *Croſſes*: the half thereof is ſo long as C H, or C K, or C F. If the aforeſaid *Quadrant*, for want of good Skill or Practice, be not well divided, or *Lines* not well drawn, the *Staves* being marked thereafter will alſo be faulty. Therefore they may be marked more exactly by *Points* equally divided, in manner as followeth.



Prepare

Prepare you a *Staff*, draw thereon a *Right Line* ſo long as your *Staff*, and take with a ſharp pair of *Compaſſes* the half Length of the *Croſs* after which you deſire to mark your *Staff*: prick it ſo often along the aforeſaid *Line*, as it can ſtand upon the ſame. Divide each of the Lengths of the half *Croſs* into 1000 *Equal Parts*. Then prick upon the *Staff* you will mark from the *Center-end*, juſt half the Length of the *Croſs*; and mark there a ſmall thwart *Stroke*. Off from thence prick for each *Degree* ſo many of the ſame *Parts* as the *Croſs* is divided in his half Length, like as is marked in the *Table* here annexed for every *Degree*. For the firſt *Degree* you ſhall mark off from 90 the aforeſaid thwart *Stroke* 176, for the fourth *Degree* 724, for the 10 *Degree* 1918 of thoſe *Parts*, and ſo of the reſt. If you cannot divide the half *Croſs*, by reaſon he is ſo little, into 1000, divide him into 100, and leave out the two laſt *Figures*, and that ſhall ſatisfie your deſire: For 30 *Degrees* take 73, and for 40 *Degrees* 114, and for 10 *Degrees* 19 *Parts*, and ſo of the reſt.

A Table *for the Diviſion of the* Croſs-Staff.

D.	Parts	D.	Parts.	D.	Parts.
1	176	31	7675	61	28667
2	355	32	8040	62	30108
3	538	33	8418	63	31653
4	724	34	8807	64	33315
5	913	35	9210	65	35107
6	1106	36	9626	66	37046
7	1303	37	10057	67	39152
8	1504	38	10503	68	41445
9	1708	39	10965	69	43955
10	1918	40	11444	70	46713
11	2131	41	11943	71	49758
12	2349	42	12460	72	53197
13	2572	43	12998	73	56912
14	2799	44	13558	74	61154
15	3032	45	14142	75	65958
16	3270	46	14751	76	71445
17	3514	47	15386	77	77769
18	3764	48	16051	78	85144
19	4019	49	16746	79	95854
20	4281	50	17475	80	104301
21	4550	51	18239	81	117062
22	4826	52	19042	82	133007
23	5108	53	19887	83	153499
24	5399	54	20777	84	180811
25	5697	55	21716	85	219038
26	6003	56	22708	86	276332
27	6318	57	23759	87	371885
28	6643	58	24874	88	561810
29	6976	59	26059	89	1135891
30	7320	60	27321	90	*Endleſs.*

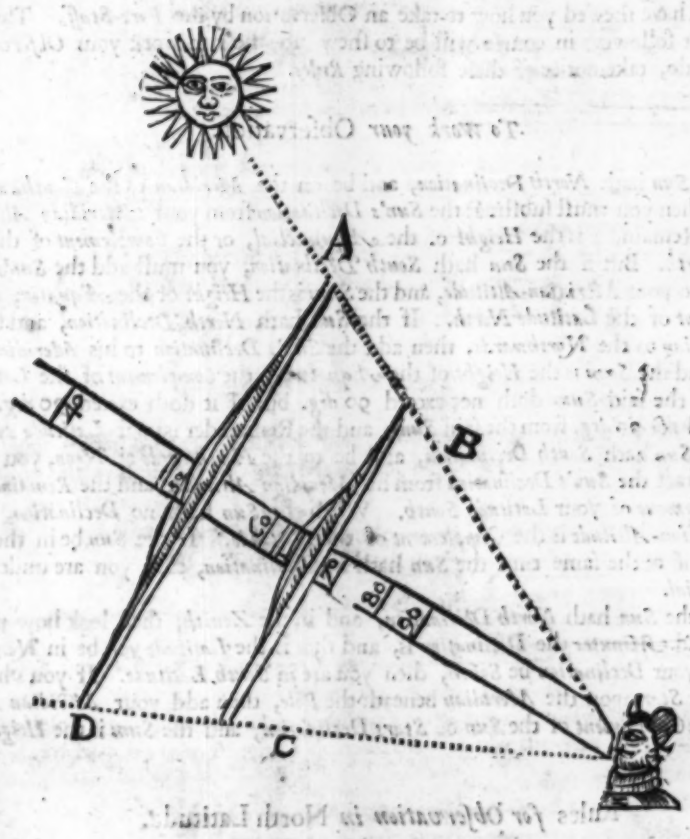
CHAP. XIII.

How to uſe the Croſs-Staff.

SEt the end of the *Croſs-Staff* to the outſide of the *Eye*, ſo that the end of the *Staff* come to ſtand right with the *Center* of the *Motion* of the *Sights*. Then move the *Croſs* ſo long off from you or towards you, holding it right up and down, and winking with your other *Eye*, till that the upper end come upon the middle or *Center* of the *Sun* or *Star*, and the lower end right with the *Horizon*, the *Croſs* then ſhall ſhew upon the ſide of the *Staff* belonging thereunto, the *Degrees* of the *Altitude* of the *Sun* or *Star*. Note, The *Staff* is marked with two *Lines* of *Numbers*, with 90 *Degrees* next the *Eye*, and diminiſhing from 90 to 80 and 70, 60 towards the outmoſt end: The *Complement-Sine* beginneth towards the *Eye-end*, and encreaſeth contrarywiſe towards the outmoſt end, as from 10, to 20, 30. The firſt *Number* ſheweth you the *Altitude*, the ſecond *Number* is the *Sun's diſtance* from the *Zenith*.

The *Sun* or *Stars* being high elevated from the *Horizon*, the *Croſs* cometh nearer the *Eye* than when they are but a little elevated, and do ſtand neer the *Horizon*; thereby the *eye* maketh (ſeeing now to the lower, and then again to the upper end of the *Croſs*) greater motion

motion in looking up and down, than when the *Sun* or *Star* doth ſtand low. And inſomuch the *Center* of the *Sight*, by ſuch looking up and down together with the end of the *Staff*, a Man ſeeth then ſmaller *Angles* then if it did remain ſtedfaſt, in regard whereof the *Croſs* cometh nearer to the *Eye* than it ſhould, and there is found too much *Altitude*. This being found by many, beſides my ſelf, by experience, they were therefore wont to cut off a piece of the end of their *Staff*, or ſet the *Croſſes* a *Degree* and ½ or two *Degrees* nearer the *Eye*; but it is not the right means for to amend the aforeſaid *Errors*. The beſt means of all in my opinion is this; That upon each ſeveral *Height* which men will obſerve, they do try with two *Croſſes* ſet upon the like *Degrees*, how the *Staff* muſt be ſet, that they may ſee the end of the ſame two *Croſſes* right one with the other.



Having found that, and then taking off one of the *Croſſes*, and ſetting the *Staff* again, in the ſame manner as before, all *Errours* will be ſo prevented, which by the lifting up or caſting down of the *Eye*, might any manner of way happen.

EXAMPLE.

I deſire to obſerve the *Sun* or any *Star* in the *South*: I make my Eſtimation, as neer as I can, how high that ſhall ſtand, or take the *Height* of them a little before they ſhall come to the *South*, which I take to be 50 *Degrees*. I ſet therefore the two

Croſſes each upon their 50 *Degrees*, and the end of the *Staff* in the hollow of the *Eye-bone*, on the outſide of the *Eye*, and bow the *Head* forward or backward, or over the one ſide or the other, till I ſee the utmoſt end of both the *Croſſes* right one with the other, according as is ſhewn by theſe *Lines* A B and C D, as is apparent enough by the foregoing *Figure*; That the *Sight-beams* over the ends of the *Croſſes* ſhall then agree with the *Lines* which might be drawn over the end of the *Croſſes*, to the *Point* or *Center* at the end of the *Staff*, which doth agree with the *Center* of the *Quadrant*, or the beginning of the *Equal Points* upon which the *Staff* is marked. Keeping in memory ſuch ſtanding of the *Staff*, I take off the one *Croſs*, and ſet the *Staff* again in the aforeſaid manner to the *Eye*, and obſerve without any errour of the *Eye*.

In taking the *Height* of the *Sun* with the *Croſs-Staff*, Men do uſe red or blew *Glaſſes*, for the ſaving and preſerving the *Eyes*; yet it is notwithſtanding a great let, and very troubleſom for the *Sight*, eſpecially if it be high: therefore the *Quadrant* and *Back-Staff* is much better, as will be ſhewed in the next *Chapter*.

Thus I have ſhewed you how to take an Obſervation by the *Fore-Staff*. The next thing that followeth in courſe will be to ſhew you how to work your *Obſervation*; which to do, take notice of theſe following *Rules*.

To Work your Obſervation.

IF the *Sun* hath *North Declination*, and be on the *Meridian* to the *Southwards* of you, then you muſt ſubſtract the *Sun's Declination* from your *Meridian Altitude*, and that Remainder is the *Height* of the *Æquinoctial*, or the *Complement* of the *Latitude North*. But if the *Sun* hath *South Declination*, you muſt add the *Sun's Declination* to your *Meridian Altitude*, and the *Sum* is the *Height* of the *Æquator*, or the *Complement* of the *Latitude North*. If the *Sun* hath *North Declination*, and be on the *Meridian* to the *Northwards*, then add the *Sun's Declination* to his *Meridian Altitude*, and the *Sum* is the *Height* of the *Æquator*, or the *Complement* of the *Latitude South*, if the ſaid *Sum* doth not exceed 90 *deg.* but if it doth exceed 90 *deg.* you muſt ſubſtract 90 *deg.* from the ſaid *Sum*, and the Remainder is your *Latitude North*.

If the *Sun* hath *South Declination*, and be to the *Northwards* at *Noon*, you muſt then ſubſtract the *Sun's Declination* from his *Meridian Altitude*, and the *Remainder* is the *Complement* of your *Latitude South*. When the *Sun* hath no *Declination*, then the *Meridian-Altitude* is the *Complement* of the *Latitude*. If the *Sun* be in the *Zenith*, and if at the ſame time the *Sun* hath no *Declination*, then you are under the *Æquinoctial*.

But if the *Sun* hath *North Declination*, and in the *Zenith*, then look how many *Degrees* and *Minutes* the *Declination* is, and that is the *Latitude* you be in *North*.

But if your *Declination* be *South*, then you are in *South Latitude*. If you obſerve the *Sun* or *Star* upon the *Meridian* beneath the *Pole*, then add your *Meridian Altitude* to the *Complement* of the *Sun* or *Stars Declination*, and the *Sum* is the *Height* of the *Pole*.

Rules *for Obſervation in* North Latitude.

SUppoſe I am at *Sea*, and I obſerve the *Sun's Meridian Altitude* to be 39 *deg.* 32 *min.* and the ſame time the *Sun's Declination* is 15 *deg.* 20 *min. North*; I demand the *Latitude* I am in.

	deg.	*min.*	
The Meridian Altitude	39	32	
The Declination North, *ſubſt.*	15	20	
The Complement *of the* Lat.	24	12	
	90	00	
The Latitude *I am in*	65	48	*North.*

Suppoſe

Suppoſe I were in a *Ship* at *Sea* the 18th of *April*, *Anno* 1667. and by Obſervation I find the *Sun's Meridian Altitude* to be 62 *deg.* 15 *min.* The *Latitude* is required.

	deg.	*min.*	
The Meridian Altitude	62	15	
The Declination North, *ſubſt.*	14	18	
The Complement *of the* Latitude	47	57	
	90	00	
The Latitude *I am in, required*	42	03	

Admit you were in a *Ship* at *Sea* the 5th of *November*, *Anno* 1679. and I find the *Sun's Meridian Altitude* to be 24 *deg.* 56 *min.* The *Latitude* is required I am in.

	deg.	*min.*	
The Meridian Altitude	24	56	
The Declination South, *add*	18	37	
The Complement *of the* Latitude	43	33	
	90	00	
The Latitude *I am in*	46	27	

Suppoſe a *Ship* at *Sea* the 28th of *May*, *Anno* 1666. and I find the *Sun's Meridian Altitude* by Obſervation 56 *deg.* 45 *min.* The *Latitude* is required I am in.

	deg.	*min.*	
The Meridian Altitude	56	45	
The Declination North, *Subſt.*	22	46	
The Complement *of the* Latitude	33	59	
	90	00	
The Latitude *required I am in*	56	01	

Admit a *Ship* at *Sea* the 11th of *June* 1668. and find the *Sun's Meridian Altitude* by Obſervation 79 *deg.* 30 *min. North*, It is required the *Latitude* I am in.

	deg.	*min.*	
The Meridian Altitude	79	30	
The Declination North	23	31	*add.*
	103	01	
	90	00	
The Latitude *I am in*	13	01	*required.*

Suppoſe I were at *Sea* the 14th of *May* 1693. and the *Meridian Altitude* of the *Sun* was 69 *deg.* 07 *min. North*, I demand the *Latitude* the *Ship* is in at that time.

	deg.	*min.*	
The Meridian Altitude	69	07	
The Declination North	20	53	*add.*
	90	00	
	90	00	
The Ship *is under*	00	00	*the* Æquinoctial.

Rules *for Observation in* South Latitude.

SUppose I at *Sea* in a *Ship* the second of *June*, *Anno* 1666. and I find the *Sun's Meridian Altitude* by Observation to be 64 *deg.* 45 *min.* The *Latitude* the *Ship* is in, is required.

	deg.	*min.*	
The Meridian Altitude North	64	45	
The Declination North, *add*	23	15	
The Complement *of the* Latitude	88	00	
	90	00	
The Latitude *the* Ship *is in*	02	00	*South.*

Suppose a *Ship* at *Sea* the 28th of *December*, *Anno* 1695. and in *Longitude* 169 *deg. East*, and I find the *Meridian Altitude* by Observation to be 59 *deg.* 52 *min.* The *Latitude* the *Ship* is in, is required. The *Declination* in the *Meridian* of *Bristol* for the 28th of *December*, is 22 *deg.* 25 *min.* and the daily difference of *Declination* is at this time 8 *min.* Therefore if you look in the *Table of Proportion* following, you will find the *Proportional Minutes* to be about 4, which you must add to the *Declination* of the *Meridian* of *Bristol*, and the *Sum* will be the true *Declination* for the *Longitude* 169 *deg. East*, which is 22 *deg.* 29 *min.*

	deg.	*min.*	
The Meridian Altitude North	59	52	
The Declination South, *substr.*	22	29	
The Complement *of the* Latitude	37	23	
	90	00	
The Latitude *the* Ship *is in, which was*	52	37	*required.*

Suppose I were at *Sea* in a *Ship* the 29th of *June*, 1679. and I find the *Sun's Meridian Altitude* to be 62 *deg.* 39 *min. North*, The *Latitude* is required.

	deg.	*min.*	
The Meridian Altitude North	62	23	
The Declination North, *add*	22	26	
The Complement *of the* Latitude	84	49	
	90	00	
The Latitude *the* Ship *is in*	05	11	*South.*

Admit I am in a *Ship* at *Sea* the 20th of *January* 1667. the *Sun's Declination* 20 *deg.* 4 *min.* and the *Sun's Meridian Altitude* 79 *deg.* 36 *min. South*, I require the *Latitude* the *Ship* is in.

Answer, 9 *deg.* 30 *min. South.*

Admit a *Ship* were at *Sea*, the *Sun's Declination* 13 *deg.* 53 *min. South*, and the *Sun's Meridian Altitude* 80 *deg.* 43 *min. South*, The *Latitude* is required.

	deg.	*min.*	
The Declination South	13	53	
The Meridian Altitude	80	43	*add.*
	94	36	*the Sum:*
Substr.	90	00	
The Latitude *the* Ship *is in*	04	36	*South.*

If you observe the upper part of the *Sun*, you must substract 16 *min.* But to the contrary, if you observe the lower part of the *Sun*, you must add 16 *min.* for the *Sun's Diameter*, and the *Sum* will be the true *Altitude* of the *Sun's Center.*

Rules

Rules *for Obſerving the* Stars.

SUppoſe I am at *Sea*, and obſerve the Brighteſt of the 7 *Stars* upon the *Meridian*, and find his *Meridian Altitude* to be 47 *deg.* 20 *min.* and the *Latitude* were required.

	deg.	*min.*	
The Declination *of this* Star *is*	23	03	*North.*
The Meridian Altitude	47	20	
Subſtract the North Declination	23	03	
The Complement *of the* Latitude	24	17	
	90	00	
The Latitude *I am in*	65	43	

Admit I were at *Sea*, and obſerve *Hydra's Heart* on the *Meridian*, his *Altitude* is 36 *deg.* 15 *min.* and his *Declination* is 7 *deg.* 15 *min. South*, The *Latitude* of the Place is demanded.

	deg.	*min.*	
The Meridian Altitude *is*	36	15	
The Declination *is* South	07	15	*add.*
The Height *of the* Æquinoctial *above*	43	30	*the* Horizon.
	90	00	
The Latitude *the* Ship *is in*	46	30	*required.*

This you ſee is plain, and needs no further *Precept* but what is already ſaid.

CHAP. XIV.

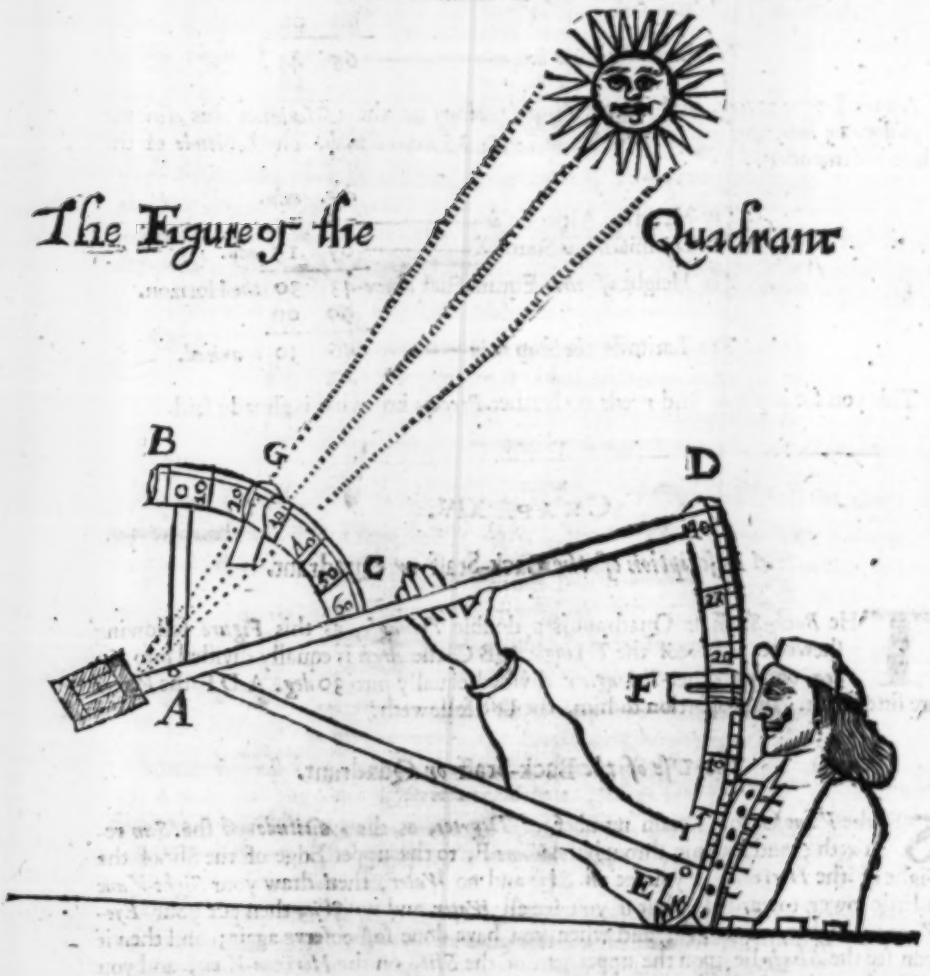
A Deſcription of the Back-Staff *or* Quadrant.

THe *Back-Staff* or Quadrant is a double *Triangle*, as this *Figure* following ſheweth; whereof the *Triangle* A B C the *Arch* is equally divided into 60 *deg.* and the other *Triangle* is divided equally into 30 *deg.* A D F the *Vanes* are fitted near. In proportion to him, the Uſe followeth.

The Uſe of the Back-Staff *or* Quadrant.

SEt the *Vane* G to a certain number of *Degrees*, as the *Altitude* of the *Sun* requireth; and looking through the *Vane* F, to the upper Edge of the Slit of the Sight of the *Horizon*, if you ſee all *Skie* and no *Water*, then draw your *Sight-Vane* a little lower towards E: but if you ſee all *Water* and no *Skie*, then put your *Eye-Vane* up higher towards F; and when you have done ſo, obſerve again; and then if you ſee the *Shade* lie upon the upper part of the *Slit*, on the *Horizon-Vane*, and you at the ſame time do ſee the *Horizon* through the *Sight-Vane*, then that is all you can do untill the *Sun* be riſen higher; and tending the *Sun* until he be upon the *Meridian*, you will perceive he is deſcending, or as we commonly ſay he is fallen, you will ſee nothing but *Water*; your *Vanes* faſt in this poſture, you have done obſerving the *Sun* upon the *Meridian* that day: Therefore reckon the *Degrees* from B to the upper ſide of the *Vane* G; to it add the number of *Degrees* from E to the *Eye-Sight*, and their *Sum* is the *Diſtance* of the *Sun* from the *Zenith* to the upper Edge of the *Sun*; to which *Sum* if you add 16 *minutes*, which is the *Sun's Semidiameter*, you will have the true diſtance of the *Sun's Center* from the *Zenith* or *Complement* of the *Meridian Altitude*. Note this, If you obſerve the upper *Limb* of the *Sun* by the upper

per part of the *Shade*, then it is the upper *Limb* that gives the *Shade*; but if you obſerve the lower part of your *Shade*, then it is the lower ſide of the *Sun* that gives the *Shade*: Therefore you muſt ſubſtract 16 *min.* from what your *Back-Staff* gives you, and the *Sum* or *Difference* gives you the right *Diſtance* of the *Sun* from the *Zenith*. You may have the *Altitude* of the *Sun* from your *Quadrant*, if you work thus; from C to G is 40 *deg.* for the *Vane* ſtands at 20 *deg.* from D to F is 16 *deg.* being added together makes 56, the *Altitude* or *Height* of the *Sun* above the *Horizon*, which you may uſe as you were ſhewn by the *Fore-Staff*: But in regard the *Engliſh Navigators* work their Obſervation by the *Complement* of the *Sun's Altitude*, when he is upon the *Meridian*, being ſo ready to be counted by their *Quadrant*; Therefore we will direct you in general, and after in particular *Rules*.



Firſt, If the *Sun* hath *North Declination*, and you in *North Latitude*, and the *Sun* upon the *Meridian*, *South* of you; then if you add the *Sun's Declination* to his *Zenith-Diſtance*, that is the *Complement* of the *Sun's Meridian Altitude*, the *Sum* will be the *Latitude* you are in.

But if the *Sun* hath *South Declination*, you muſt ſubſtract the *Complement* of the *Meridian Altitude*, and the Remainder will be the *Latitude* the *Ship* is in.

If you be to the *Southward* of the *Æquinoctial*, and the *Sun* to the *Northwards* of the *Æquinoctial*, in ſuch caſe you muſt add the *Sum* of the *Declination* to the *Zenith-diſtance*, and the *Sum* will be your *Latitude South*.

But if the *Sun* be to the *Northwards* of the *Æquinoctial* (that is, have *North Declination*)

clination) you muſt ſubſtract the *Declination* from the *Zenith-diſtance*, and the Remainder will be the *Latitude South*.

If you underſtand the fore-going *Rules* given of the Uſe of the *Fore-Staff*, you cannot miſtake the Uſe of the *Quadrant* or *Back Staff*.

We will now come to *Examples* what are needful.

Obſerve theſe Rules *for* North Latitude.

ADmit we were in a *Ship* at *Sea* the fifth of *May*, *Anno* 1694. and by Obſervation I find the upper ſide of the *Sun* to be diſtant from the *Zenith* 37 *deg.* 36 *min.* the *Sun* being upon the *Meridian*, I require the *Latitude* the *Ship* is in.

	deg.	*min.*	
The Sun's Diſtance *from the* Zenith	37	36	*his upper Edge.*
The Sun's Semidiameter, *add*	00	16	
The Center *of the* Sun *from the* Zenith	37	52	
North Declination	19	02	
The Latitude *required, the* Ship *is in*	56	54	

Suppoſe a *Ship* at *Sea* the 29th of *July*, *Anno* 1682. and I find the *Complement* of the *Sun's Meridian Altitude* by obſervation to be 32 *deg.* 54 *min.* The *Latitude* of that Place the *Ship* is in, is required.

	deg.	*min.*
The Complement *of the* Altitude *is*	32	54
The Sun's Semidiameter *add to it*	00	16
The Diſtance *of the* Sun's Center *from* Zenith	33	10
North Declination, *add*	16	07
The Latitude *the* Ship *is in*	49	17

Suppoſe a *Ship* were at *Sea* the 13th of *Sept.* 1683. and I find the *Complement* of the *Sun's Meridian Altitude*, or *Diſtance* from the *Zenith*, 45 *deg.* 42 *min.* I demand what *Latitude* the *Ship* is in.

	deg.	*min.*
The Complement *of the* Altitude *is*	45	42
The Sun's Semidiameter *add to it*	00	16
The Diſtance *of the* Center *of the* Sun	45	58
The Declination South, *ſubſtract*	00	07
The Latitude *the* Ship *is in*	45	51

Admit a *Ship* were at *Sea* the fourth of *December*, *Anno* 1690. and the *Complement* of the *Sun's Meridian Altitude* that day were 49 *deg.* The *Latitude* the *Ship* is in, is required.

	deg.	*min.*
The Complement *of the* Meridian Altitude	49	07
The Sun's Semidiameter *Add*	00	16
The Center *of the* Sun *diſtant from the* Zenith	49	23
The Sun's Declination South, *ſubſtract*	23	30
The Latitude *the* Ship *is in* North	25	53

Suppoſe I were in a *Ship* at *Sea* the 23d of *May*, *Anno* 1695. and I am alſo in *Longitude* to the *Eaſt* of the *Meridian* of *London* 135 *deg.* and I find the *Complement* of the *Meridian Altitude* by Obſervation to be 13 *deg.* 12 *min.* The *Latitude* is required.

Declination

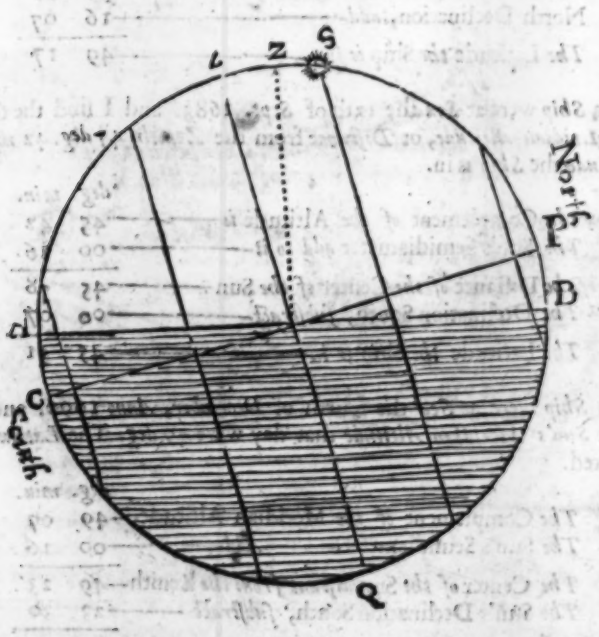
	deg.	min.
Declination *in the* Meridian *of* London	22	17
The Proportional Minutes, *ſubſtract*	00	03
The Sun's Declination *in the* Meridian *given*	22	14
The Complement *of the* Sun's Altitude	13	12
The Sun's Semidiameter, *added*	00	16
The True Zenith Diſtance *of the* Sun	13	28
The True Latitude *the* Ship *is in* North	08	46

That is, by reaſon the *Sun* is to the *Northward* of my *Zenith*, and the *Declination* more than the true *Diſtance* from the *Zenith* or *Complement* of the *Meridian Altitude*; therefore ſubſtract 13 *deg.* 28 *min.* from 22 *deg.* 20 *min.* and the Remainder is the true *Latitude* 8 *deg.* 52 *min. North.*

EXAMPLE.

Let the *Complement* of the *Sun's Altitude* be Z S, the *Altitude* 76 *deg.* 32 *min.* in the *North* B S, the *Declination North* E S 22 *deg.* 14 *min.* if you add the *Altitude* S B 76 *deg.* 32 *min.* to the *Declination* S E 22 *deg.* 14 *min.* the *Sum* is B E 98 *deg.* 46 *min.* the *Diſtance* of the *Æquinoctial* from the *Horizon* in the *North* B Z 90 *deg.* being ſubſtracted from it, remaineth for Z E, the *Diſtance* of the *Æquinoctial* from the *Zenith* towards the *South*, 8 *deg.* 46 *min.* juſt B P the *Latitude* of the Place, and *Altitude* of the *Pole* above the *Horizon.*

	d.	m.
B S	76	32
S E	22	14
B E	98	46
	90	00
B	08	46



Let the *Complement* of the *Sun's Altitude* be Z S 13 *deg.* 28 *min.* the *North Declination* E S 22 *deg.* 14 *min.* being more than the *Diſtance* of the *Sun* from the *Zenith*, ſubſtract Z S 13 *deg.* 28 *min.* the *Complement* of the *Altitude* from S E the *Declination*, there remaineth 8 *deg.* 46 *min.* the *Diſtance* of the *Æquinoctial* from the *Zenith* Z E or *Latitude* of the Place B P, as before. I have been the more large on this, by reaſon I would have *Learners* perfect in it, it being moſt uſeful *Queſtions.*

When

When that you Sail far *Northward* or *Southward*, that the *Sun* goeth not down, as they find that Sail about the *North Cape*, and to *Spitsberghen*, or *Greenland*; and that you would observe the *Altitude* by the *Sun*, also when he is in the *North* at the lowest,

First, There must be added to the *Altitude* of the *Sun* taken above the *Horizon*, the *Complement* of the *Sun's Declination*; that is, the *Distance* betwixt the *Sun* and the *Pole*, that *Number* sheweth the *Altitude* of the *Pole*.

Secondly, Or else the observed *Altitude* must be substracted from the *Declination*, that which remaineth is the depression or depth of the *Æquinoctial* under the *Horizon* in the *North*, just to the *Altitude* of the same in the *South*, the *Complement* thereof is the *Altitude* or *Height* of the *Pole*.

Thirdly, If you take the *Complement* of the *Sun's Altitude*, and substract from it the *Complement* of the *Sun's Declination*, there remaineth the *Distance* of the *Pole* from the *Zenith*, or the *Altitude* of the *Æquinoctial* in the *South*; the *Complement* thereof is the *Altitude* or *Height* of the *Pole*.

Fourthly, Or else if you add the *Declination* to the *Complement* of the *Altitude*, and you substract 90 *Degrees* out of that *Number*, there remaineth the *Depth* of the *Æquinoctial* in the *North* under the *Horizon*; that being substracted out of 90, there remaineth the *Altitude* of the *Pole*.

Directions *for Observation in* South Latitude.

ADmit a *Ship* at *Sea* the 7th of *July*, *Anno* 1695. and I am in *Longitude* 135 *deg. East*, and the *Sun* being upon the *Meridian*, I find the *Complement* of his *Meridian Altitude* by Observation to be 42 *deg.* 34 *min. North*; The *Latitude* is demanded, the *Ship* is in.

	deg.	*min.*	
The Complement *of the* Meridian Altitude	42	34	
The Sun's Semidiameter, *add*	00	16	
The Sun's Center *distant from the* Zenith	42	50	
The Declination North, *substract*	21	16	
The Latitude *the* Ship *is in*	21	34	

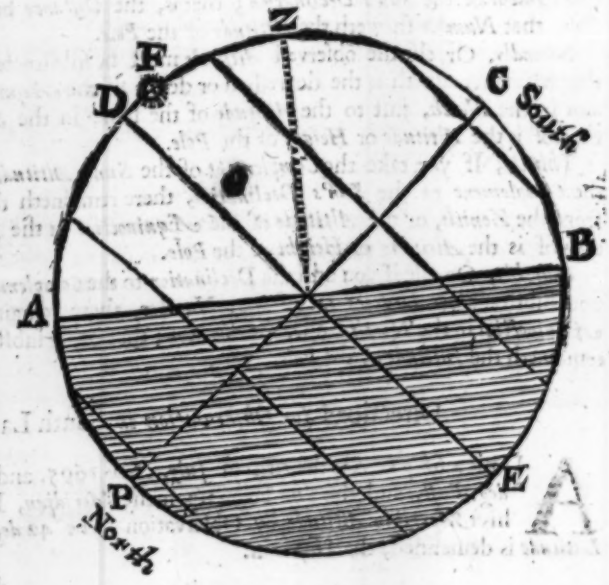
Admit I were in a *Ship* the fifth of *November*, *Anno* 1687. and in *Longitude* 120 *deg. West*, and the *Complement* of the *Sun's Meridian Altitude* by Observation is 31 *deg.* 37 *min. North*; The *Latitude* is required, the *Ship* is in.

	deg.	*min.*	
The Complement *of the* Meridian Altitude	31	37	
The Sun's Semidiameter, *add*	00	16	
The Sun's Center *distant from the* Zenith	31	53	
The Declination South	18	37	
The Proportional Minutes	00	05	*Added.*
The Sun's Declination *in the* Meridian *given*	18	42	
Which add to the Zenith-distance	31	53	
The Latitude *the* Ship *is in*	50	35	

Suppose I were in a *Ship* at *Sea* to the *Southwards* of the *Æquinoctial*, the third of *January*, *Anno* 1683. and I find the *Sun* upon the *South* part of the *Meridian*, and by Observation his *Meridian Altitude* is 75 *deg.* 38 *min.* The *Latitude* the *Ship* is in, is required.

	deg.	*min.*
The Complement *of the* Meridian Altitude	14	22
The Sun's Semidiameter, *add*	00	16
The Sun's Center *from the* Zenith	14	38
The Declination South	21	28
The Latitude *the* Ship *is in* South	06	50

EXAMPLE.



In this *Figure* let C be the *South*, and P the *North Pole*, D E the *Æquinoctial*, A B the *Horizon*, Z the *Zenith*. Let A F be the *Altitude* of the *Sun* above the *Horizon*, in the *North* 58 *deg.* D F *South Declination* 8 *deg.* If you ſubſtract the *Declination* D F 8 *deg.* from F A the *Altitude*, there remains 50 *deg.* the *Height* of the *Æquinoctial* above the *Horizon* in the *North*; that being deducted out of 90 *deg.* there remaineth A P 40 *deg.* for the *Depth* of the *North Pole* under the *Horizon*, juſt to B C the *Elevation* or *Altitude* of the *South-Pole* above the *Horizon* in the *South.*

	deg.	*min.*
Sun's Altitude	58	00
South Declination	08	00
Height *of the* Æquator	50	00
	90	00
The Latitude *is*	40	00

The Uſe of the Fore-Staff *in* South Latitude *for the* Sun *and* Stars.

SUppoſe I were at *Sea* in a *Ship* the ſecond of *June*, *Anno* 1694. and I find the *Sun's Meridian Altitude* by Obſervation to be 59 *deg.* I demand the *Latitude* the *Ship* is in.

	deg.	*min.*
The Meridian Altitude North	59	00
The Declination North, *add*	23	15
The Complement *of the* Latitude	82	15
	90	00
The Latitude *required*	07	45

Admit I were at *Sea* in a *Ship* to the *Southward* of the *Æquinoctial*, the 12th of *January*, *Anno* 1682. and in *Longitude* 135 *Eaſt*; and I find by Obſervation the *Meridian Altitude* 63 *deg.* 34 *min. North*: There is required the *Latitude* the *Ship* is in.

The *Declination* for this *Meridian*, the *Lands-end* of *England*, is about 19 *deg.* 33 *min.* the daily *difference* in *Declination* at this time is 14 *min.* Therefore if you look in the *Table* of *Proportion*, you will find the *Proportional Minutes* to be 5, which you muſt add to the *Declination* of the former *Meridian*, and the *Sum* will be the true *Declination* for the *Longitude* of 135 *deg. Eaſt*, which is 19 *deg.* 38 *min.*

The

	deg.	min.	
The Meridian Altitude	63	34	
The Declination South	19	38	*ſubſtract.*
The Complement *of the* Latitude	43	56	
	90	00	
The Latitude *required*	46	04	

Admit a *Ship* were at *Sea* the third of *Auguſt*, *Anno* 1675. and I find the *Sun's Meridian Altitude* to be 59 *deg.* 36 *min. North*, The *Latitude* is required.

	deg.	min.
The Meridian Altitude North	59	36
The Declination North, *add it*	14	42
The Complement *of the* Latitude	74	18
	90	00
The Latitude *the* Ship *is in*	15	42

Suppoſe a *Ship* at *Sea*, the *Sun's Declination* being 21 *deg.* 42 *min. South*, and the *Sun's Meridian Altitude* 74 *deg.* 23 *min. South*, The *Latitude* is required the *Ship* is in.

	deg.	min.
The Complement *of the* Sun's Meridian Altitude	15	37
Subſtracted from the Sun's Declination	21	42
The Latitude *the* Ship *is in*	06	05

This being made ſo plain and eaſie to be underſtood, need no more Precedent: But obſerve this, If you obſerve the upper Edge or part of the *Sun*, you muſt ſubſtract 16 *minutes*; if the lower part, add 16 *minutes* for the *Semidiameter* of the *Sun*, and the *Sum* ſheweth the true *Altitude* of the *Center* of the *Sun*.

CHAP. XV.

Directions *for Obſerving the* Stars.

SUppoſe I am at *Sea* in a *Ship*, and I obſerve the bright *Star* in the left Foot of *Orion Rigel*, upon the *Meridian*, and find his *Altitude* 44 *deg.* 32 *min.* his *Declination* is 8 *deg.* 37 *min. North*; The *Latitude* is required, the *Ship* is in.

	deg.	min.	
The Meridian Altitude	44	32	
The Declination North	08	37	*ſubſtract.*
The Complement *of the* Latitude	35	55	
	90	00	
The Latitude *the* Ship *is in*	54	05	

Suppoſe I am at *Sea*, and I obſerve the *South Balance* of *Libra*, and by Obſervation of the *Star* upon the *Meridian*, I find his *Altitude* 39 *deg.* 27 *min.* and his *Declination South* 14 *deg.* 27 *min.* I require the *Latitude* I am in.

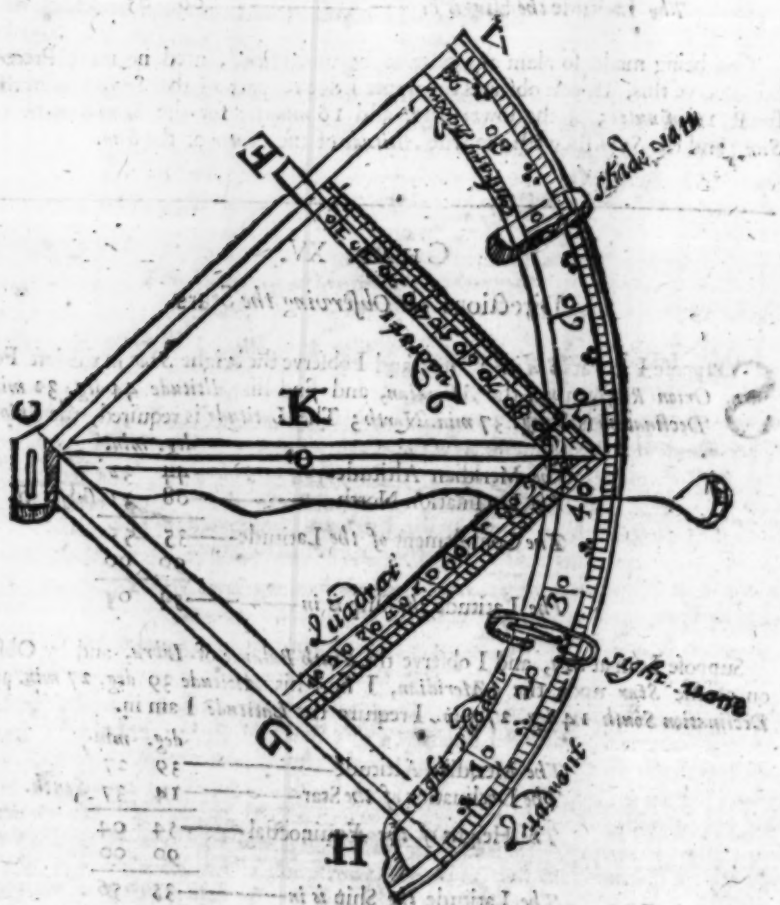
	deg.	min.	
The Meridian Altitude	39	27	
The Declination *of the* Star	14	37	*South.*
The Height *of the* Equinoctial	54	04	
	90	00	
The Latitude *the* Ship *is in*	35	56	

I have furniſhed the *Practitioner* with all uſeful and needful *Examples*, which I thought neceſſary for direction, which explains the following *Tables*, and ſhews the moſt eaſie and perfect way of Obſervation, and how to work them on either ſide the *Æquator*. Others I confeſs have been larger, but none more plain: for he that cannot underſtand theſe *Rules* and *Directions*, is not fit to be a *Mate* of any *Ship* or *Veſſel*, nor fit to be ranked among the *Ingenious Mariners*.

CHAP. XVI.

The Deſcription and Uſe of the moſt Uſeful Quadrant *for the taking* Altitudes *on* Land *or* Sea, *of the* Sun *or* Stars, *backwards or forwards, or any other* Altitude *of* Hills, Trees, Steeples, *or* Caſtles, *or any thing whatever.*

THis *Quadrant* is made of well-ſeaſoned and ſmooth dry *Box Wood* or *Pear-tree*. The *Sides* or *Semidiameter* of the *Circle* is about 19 or 20 *Inches*. C V and C H the *Arch* of the *Quadrant* is divided into 90 *Degrees* firſt, and each *Degree* into 6 *Equal Parts*, each *Part* being 10 *Minutes*, which is near enough for *Sea* or *Land Obſervations*, and numbred as you ſee from 10 to 90 *deg.* The two *Sides* next the *Center*, E F and G F, are divided each of them into 100 *Equal Parts:*



That

That which is next the *Horizon* G F H, are called the *Parts of Right Shadow*: the other *Side* E F V, is the *Parts of contrary Shadow*. In the *Center* at C there is a *Braſs-Pin*, and on it hang the *Thred* and *Plummet*; and on the Side there is a *Sight* made of *Braſs* at E. There is alſo an *Horizon-Vane*; let in upon the *Center* C, with two *Laggs* that the *Braſs-Pin* comes upon in the middle of the *Slit*; and a *Shade-Vane* and *Sight-Vane*, for *Back-Obſervation*. The Uſe of the *Quadrant* is,

EXAMPLE.

Admit I am aſhore upon any *Land* or *Iſland*, and would know the *Sun's Meridian Altitude*, and true *Latitude* of the *Place*. Take the *Altitude* thus; The *String* and *Plummet* being hanged on the *Center* C, turn the *Braſs-Pin* to the *Sun*, and hold up the *Center* until the *Shade* of the *Braſs-Pin* ſtrikes on the *Sight* and *Line* of E, the *Thred* and *Plummet* playing eaſily by the Side: mark where it cuts the *Arch* of the *Quadrant*, as at F, that is the *Sun's Altitude*, and reckoned from H; and the *Latitude* is found by the ſame *Rules* as you have been given in the Uſe of the *Fore-Staff*. The beſt way to hold the *Quadrant* ſteady, is to skrew it with a *Braſs-Pin* through at K, to a *Staff* ſet perpendicular, and then you may raiſe it by degrees, as the *Sun* riſes.

PROPOSITION I.

For Back-Obſervation *at* Sea.

Take the Handle of the *Quadrant* at H in your Hand, after the *Vanes* are ſet on, and fix the *Shade-Vane*; then hold your *Quadrant* as upright as you can; then bring your *Sight-Vane* to your *Eye*, and look through your *Sight* upon the *Horizon-Vane*. You muſt be ſure to hold your *Quadrant*, ſo that the upper part of your *Shade-Vane*, may be upon the upper part of the *Slit* on your *Horizon-Vane*, and look through the *Slit* for the *Horizon*: But if you cannot ſee the *Horizon*, but all *Skie* and no *Water*, you muſt draw your *Sight-Vane* a little lower down towards H; but if, on the contrary, you do ſee all *Water* and no *Skie*, then ſlide your *Sight-Vane* a little higher towards V, and then make Obſervation again; and then if the upper part of the *Shade* do lie upon the upper part of the *Slit*, and you ſee the *Horizon* at the ſame time, then it is well, and you muſt wait a little longer as your Judgment thinks fit, till the *Sun* is upon the *Meridian*, and ſo do as you did before; and if the *Sun* be to the *Weſtward* of the *Meridian*, and falling, you will ſee all *Water* and no *Skie*, the Work is done for that time and day. Then look what *Degrees* the *Shade-Vane* is put at, which in the *Figure* is at 70 *deg.* which note. Look alſo what *Degrees* and *Minutes* do ſtand againſt your *Sight*, which ſubſtract from the former *Degrees* by the *Shade-Vane*, and the Remainder is the *Sun's Meridian Altitude*. As in the *Figure*, The *Sight-Vane* is at 25 *deg.* 30 *min.* which taken out of 70 *deg.* the Remainder is 44 *deg.* 30 *min.* the *Sun's Altitude*, or the diſtance of the upper part of the *Sun* from the *Horizon*; from which if you ſubſtract 16 *min.* which is the *Sun's Semidiameter*, the Remainder will be the *Diſtance* of the *Sun's Center* from the *Horizon*, or the true *Meridian Altitude*. And the way of working your *Obſervation*, is the very ſame as you have been given in the Uſe of the *Fore-Staff*.

PROP. II.

Any Point *being given, To find whether it be level with the* Eye, *or not.*

Take the *Quadrant* and look through the *Sight* at E and *Center-pin* C, unto the *Point* given, or the Place you would know whether it be level, or not. If the *Thred* fall on C H the *Horizontal Line*, then is the *Place* level with the *Eye*: But if it ſhould fall within, upon any of the *Diviſions*, then it is higher; if without the *Quadrant*, then it is lower than the level of the *Eye*.

PROP.

PROP. III.

To find the Height *of an* House, Steeple, Tower, *or* Tree, *from the Ground, at one Observation; and the length of the* Ladder *which will Scale it.*

If you can approach the bottom or foot of the Thing whose *Height* you desire, the thing is easily performed by this *Quadrant* or *Cross-Staff*, holding up your *Quadrant* to the Place whose *Height* you would know, and looking through the *Sight* on the Side E C, going nearer or further from it, till the *Thred* cut 45 *deg.* or fall upon 100 *Parts* in the *Quadrat*: So shall the *Height* of the Thing above the level of your *Eye*, be equal to the *Distance* between the *Place* and your *Eye*.

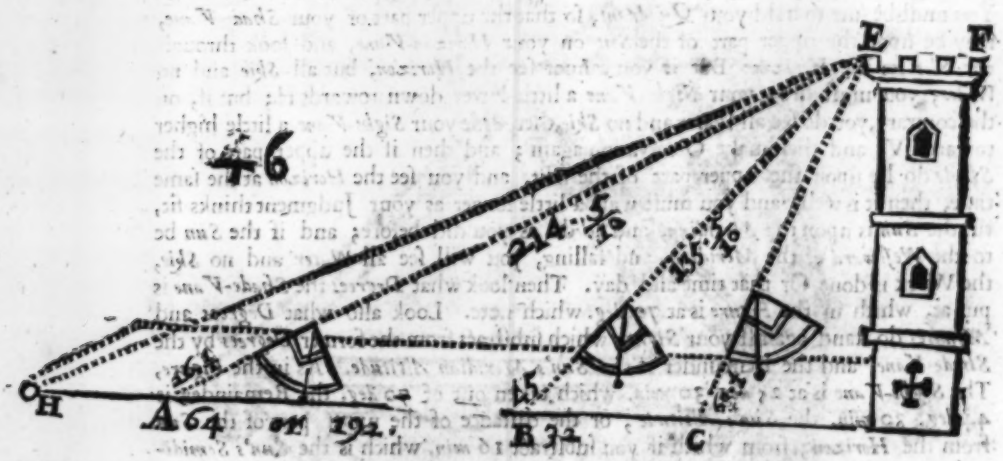
If the *Thred* fall on 50 *parts* of a right *Shadow*, or 26 *deg.* ½ or *Vanes* on the *Cross-Staff*, set to the Number of *Deg.* the *Height* is but half the *Distance*.

If the *Thred* cut 25 *Parts* in the *Quadrat*, or 13 *deg.* 55 *min.* in the *Arch* of the *Quadrant*, it is but a quarter of the *Distance*: But if it fall on 75 *Parts*, or 36 *deg.* 53, it is three quarters of the *Distance*. The *Rule* is,

As 100, *to the* Parts *on which the* Thred *falleth*:
So is the Distance, *to the* Height *required*.

And on the contrary,

As the Parts *cut by the* Thred, *are to* 100:
So is the Height, *to the* Distance.



But when the *Thred* shall fall on the parts of the contrary *Shadow*, if it fall on 50 *Parts*, or 63 *deg.* 30 *min.* as it doth at C, the *Height* is double unto the *Distance* C D. If on 25, it is four times the *Distance*. If the *Thred* fall upon the contrary *Shadow*, this is the *Rule*,

As the Parts *cut by the* Thred, *are unto* 100:
So is the Distance, *unto the* Height.

On the contrary,

As 100, *are unto the* Parts *cut by the* Thred:
So is the Height, *unto the* Distance.

These are the *Rules* Mr. *Gunter* shews by the *Quadrat*, And what hath been said of

of *Height* and *Diſtance*, the ſame may be underſtood of *Height* and *Shadow*; but here follows more uſeful *Rules* than theſe before-going.

PROP. IV.

The Diſtance *being given, To find the* Altitude.

Suppoſe E F G D were a *Tower*, or *Steeple*, or *Tree*, or *Houſe*, whoſe *Altitude* you would know, and you cannot come ſo neer as to meaſure between your *Station* of 45 *deg.* and the *Baſe* of the Thing, by reaſon of ſome *Wall* or *Moat*; yet by the Proportion of the *Line* of *Quadrature*, you may help your ſelf by going backwards.

Thus if you could not meaſure the *Diſtance* from B to D, then go backward from B to A, until the *Thred* cut the 26 *deg.* 30 *min.* of your *Quadrant*; and meaſure the *Diſtance* between B and A, as ſuppoſe it to be 32 *Foot* or *Yards*, equal to the *Height* D E 32; The whole *Line* D A being 64 *Feet* or *Yards*, which is double to the *Height*. By the *Tables*,

Suppoſe then the *Angle* made by the *Thred* on the *Quadrant* A D B, be equal to the *Angle* E A D 26: 30 *min.* and the *Diſtance* A D be 64 *Yards*, or 192 *Foot*, to find the *Height* D E, I ſay,

As the Radius 90 Degrees	100000
To the Tangent *of the* Angle *E A D* 26 deg. 30 min.	969773
So is A D 64 Yards	180618
To the Height *required*, *D E* 32 Yards	*X*, 50391

PROP. V.

The Diſtance *being given, To find the* Diſtance *from the* Eye *to the top of the* Tower.

Let the *Diſtance* A D be 192 *Feet*, the *Angle* at the *Eye* A 26 *deg.* 30 *min.* and the *Diſtance* from the *Eye* or *Hypotenuſa* A E is required.

As the Sine *of the* Angle A E D 63 *deg.* 30 *min.*	995179
Is to the Radius 90 *deg.*	10
So is A D 192 Feet	1228330
To A E 214 $\frac{5}{10}$ Feet	233151

PROP. VI.

Some part of the Diſtance *being given, To find the* Diſtance *from the* Eye *or* Hypotenuſe.

Let the Part of the *Diſtance* given be A B 96 *Feet*, and it is required to find the *Diſtance* from the *Eye* or *Hypothenuſe* E B, which is the *Length* or *Hypothenuſe* to the *Triangle* D B E. Firſt find the other *Angles* thus:

A E *is* 214 $\frac{5}{10}$ Feet, A B *is* 96 $\frac{5}{10}$ Feet	*The* Sum *is* 310 $\frac{5}{10}$	349206
	The Difference 118 $\frac{5}{10}$	307371
The Angle *at* B *is* 153 *deg.* 30. *The* Half-Tangent *is* 76 *deg.* 45.	*To* Tang. $\frac{1}{2}$ Sum *of*	1062806
	oppoſite Angle 76 deg. 45.	1370177
		1020971

The

	deg.	*min.*	
The Half-Tang. difference *is*	58	20.	
The Half-Tangent Sum	76	45	
Sum	135	05	
Taken out of	180	00	
Whoſe Complement *remains*	44	55	Angle E B D.

Then to find the *Length* of B E,

As the Sine *of the* Angle A B E 135 deg. 5 min. *or* 44 deg. 55 min.—984885
To A E 214 $\frac{5}{10}$ Feet—333142
So is the Sine *of the* Angle E A B 26 deg. 30 min.—964952
To the Diſtance *from the* Eye B E 135 $\frac{5}{10}$ Feet *or* Hypotenuſe—1298094
313209

PROP. VII.

Some part of the Diſtance *being given, To find the* Altitude.

Keep the *Angle* and *Diſtance* from the *Eye* found by the former *Propoſition.*

As the Radius 90 deg.— 10
Is to the Sine *of the* Angle E B D 44 deg. 55 min.— 984885
So is E B 135 $\frac{6}{10}$— 313225
To E D *the* Height *required*, 95 $\frac{8}{10}$ Feet—1298100

which is the ſame as before found, without ſenſible difference. By the ſame *Rule* you may find the neareſt Obſervation in the *Figure* to the *Tower*.

PROP. VIII.

To do the ſame thing by the Quadrant, *and* Scale *of* Equal Parts, *another way.*

Without *Calculation*, by your *Quadrant* or *Scale* of *Equal Parts*, you may be reſolved of all the foreſaid *Propoſitions*, by the help of a *Line* of *Chords*; you may lay it down and demonſtrate it, as you ſee the *Figure*, by the ſame *Scale* of *Equal Parts* as you meaſured, the firſt *Diſtance*, will anſwer all the reſt. This is ſo plain, it needs no other *Precept*.

Here is another way to find the *Length* of the *Scaling-Ladder* without *Calculation*, which in many Caſes is the chief thing looked after; which cannot be ſo well done by the *Quadrat*, as by obſerving the *Angles* of the *Quadrant*; and this is the beſt way I know.

Let your *Station* be any where at random, or as neer as you can come to the Foot of the *Tower* or *Wall*, for the *Ditch*, or *Moat*, or *Cannon ſhot*: As ſuppoſe at B, and obſerve there the *Angle* of the *Height* of the Thing, which let be any *Degrees* whatſoever, as here is 45 *deg.* I ſay, If you go ſo far backwards from this *Station* of B, toward H, till you make the thing appear juſt at half the aforeſaid *Angle*, which is here 22 *deg.* 30 *min.* the half of 45 *deg.* That then this *Diſtance* from B to H is the true *Length* of the *Sloap-ſide* B E, without farther trouble; and a *Ladder* of that Length will Scale the ſaid *Moat* or *Wall*, allowing only the *Height* of your *Eye* from the Ground.

PROP.

PROP. IX.

Part of the Diſtance *being given, To find the Remainder of the* Diſtance.

Let part of the *Diſtance* given be A B *96 Feet*, and the Remainder of the *Diſtance* cannot be meaſured, by reaſon of danger of *Shot*, or *Moat* of *Water*, or ſome other *Impediments*; Therefore by the *7 Rule* I found the *Angle* at B to be 44 *deg.* 55 *min.* So that the *Angle* B E D 45 *deg.* 05 *min.* is the *Complement* thereof: Which known, I ſay,

As the Radius——————————10

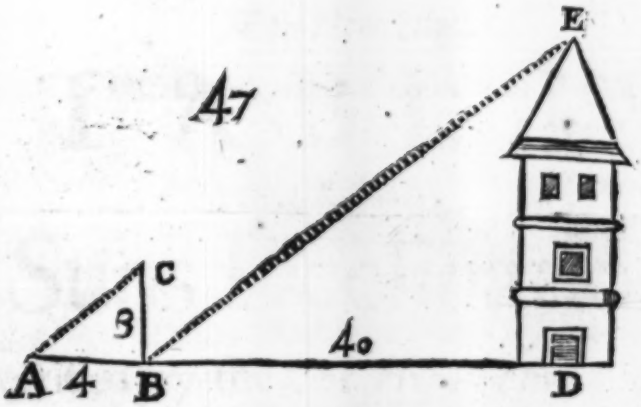
To the Sine *of the* Angle B E D 45 deg. 5 min.——98501 1
So is the Diſtance *from the* Eye B E 135 $\frac{6}{10}$ Feet——31 3225

To the Remainder *of the* Diſtance B D *96* Foot——298236

PROP. X.

By the Height *of the* Sun, *and the* Length *of the* Shadow, *To find the* Height *of any* Tree, Tower, *or* Steeple.

This *Concluſion* may be tried by a little *Quadrant* or *Pocket-Inſtrument*, by which you may take the *Sun's Altitude* to a *Degree*, $\frac{1}{2}$ or $\frac{1}{4}$, which is near enough for theſe *Concluſions*.



Suppoſe D E to be a *Turret*, *Tree*, or *Steeple*, whoſe *Height* is required to be found by the *Shadow* it makes on Level Ground, the *Rule* is thus, *viz.* Let the *Height* of the *Sun* be 37 *deg.* 00 *min.* and the *Length* of the *Shadow* 40 *Foot*, the *Rule* is,

As the Radius 90 deg.——————————10

To the Length *of the* Shadow 40 Foot——————16 0206
So is the Tangent *of the* Sun's Height 37 deg.——————9877 11

To the Height *of the* Thing *deſired*——————147917

which is found to be 30—14 *Parts*, which ſhews the *Height* to be a little above 30 *Foot*.

Here is another way to do the ſame without the help of a *Quadrant* and *Sun's Altitude*, *viz.* Set up a *Staff* of any Length, ſuppoſe 3 *Feet* in Length, as C B, and

the *Shadow* which it makes from B to A is 4 *Feet*; Because the *Shadow* of the *Tower* from the *Base* thereof to B is 40 *Feet*, I say,

As the Shadow *of the* Staff, *is to the* Height *of the* Staff:
So is the Shadow *of the* Steeple, *to the* Height *of the* Steeple.

The *Operation* may be performed by *Natural Numbers*, or by *Logarithms*, thus, *viz.*

As 4 Feet, *to* 3 Feet: *So* 40 Feet, *to* 30 Feet.

3
4 (30
40

As the Shadow *of the* Staff 4 Feet A B, Log. ——	4.0,60206
To the Length *of the* Staff 3 Feet B C —— ——	3.0,47712
So is the Shadow *of the* Steeple 40 Feet D B ——	40,1,60206
	2,47918
To the Height *of the* Tower 30 Feet D E ——	1,47712



A

A

Constant Kalendar;

OR AN

ALMANACK

For Three Hundred Years.

But more exactly ſerving for Nineteen Years,

BEING THE

CIRCLE of the MOON,

OR THE

GOLDEN NUMBER.

With New Exact

TABLES

OF THE

Suns Declination,

Rectified by the beſt *Hypotheſis*, until the LEAP-YEARS 1695.

BY

Capt. SAMUEL STURMY.

London, Printed *Anno Domini* 1668.

AN ALMANACK For XXXII. Years.

According to the *English* and *Foreign Accounts.*

Anno Dom.	*Prime.*	*Epact*	*Sund. Letter*	*Shrove Sunday.*	*Easter Sunday.*	*White Sunday.*	*Diff.*
1664	12	12	C B	Feb. 21	10	May 29	1
1665	13	23	A	5	March 26	14	0
1666	14	04	G	25	April 15	June 03	0
1667	15	15	F	17	7	May 26	1
1668	16	26	E D	2	March 22	10	0
1669	17	7	C	21	April 11	30	0
1670	18	18	B	13	3	22	1
1671	19	29	A	March 05	23	June 11	5
1672	01	11	G F	Feb. 18	7	May 26	0
1673	2	22	E	9	March 30	18	1
1674	3	3	D	March 1	April 19	June 07	5
1675	4	14	C	Feb. 14	4	May 23	0
1676	5	25	B A	6	March 26	14	0
1677	6	6	G	25	April 15	June 03	1
1678	7	17	F	10	March 31	May 19	0
1679	8	28	E	March 2	April 20	June 08	5
1680	9	9	D C	Feb. 22	11	May 30	0
1681	10	20	B	13	3	22	
1682	11	1	A	26	16	June 04	
1683	12	12	G	18	8	May 27	
1684	13	23	F E	10	March 30	18	
1685	14	04	D	March 1	April 19	June 07	
1686	15	15	C	Feb. 14	4	May 23	
1687	16	26	B	6	March 27	15	
1688	17	7	A G	26	April 15	June 03	
1689	18	18	F	10	March 31	May 15	
1690	19	20	E	March 2	April 20	June 08	
1691	1	11	D	Feb. 22	April 12	May 31	
1692	2	22	C B	7	March 27	May 15	
1693	3	3	A	Feb. 26	April 16	June 4	
1694	4	14	G	18	8	May 27	
1695	5	25	F	Feb. 3	March 24	12	

The Use of the Almanack *for* 32 Years.

THis *Table* sheweth first the *Date* of the *Years*; secondly, the *Prime*, or *Golden Number*; thirdly, the *Epact*; fourthly, the *Dominical Letter* for these *Years*; and then in their Order the Chief *Movable Feasts* (viz.) *Shrove-Sunday*, *Easter-day*, and *Whitsunday*, upon which all the rest depend. The *Foreign Account* is commonly ten days before us; but their *Movable Feasts* fall sometimes at the same time with ours, sometimes 1, 2, 3, 4, or 5 *Weeks* before ours, as you see in the last *Column* of the *Table*.

Of the Terms.

THere are four times of the *Year* appointed for the *Determining* of *Causes*; these are called *Terms*. Two of these *Terms* (viz.) *Hillary Term*, and *Michaelmas Term*, are at a constant time of the *Year*: but *Easter Term* and *Trinity Term* are sooner or later, as those *Feasts* happen. Each of these *Terms* hath several *Returns*, and each *Return* hath four *Days* belonging to it. The first is the *Day* of *Return* or *Essoin*, for the *Defendant* in a *Personal Action*, or the *Tenant* in a *Real Action*. The second is the *Day* of *Exception*, for the *Plaintiff* or *Defendant* to lay an *Exception*. The third is the *Day* whereon the *Sheriff* must return the *Writ*. The fourth is the *Day* of *Appearance* in the *Court*. These four *Days* follow each other in order, except a *Sunday* or *Holyday* take up any of them, and then the *Day* following serves for both Occasions.

The Beginning and End of *Hillary Term* and *Michaelmas Term*, with all their *Returns*, you shall find in this following *Kalendar*, which are constant if no *Sunday* hinder them.

Easter

Easter Term begins *Wednesday* Fortnight or 17 *Days* after *Easter*, and ends the *Munday* after *Holy-Thursday*, or the *Munday* before *Whitsunday*: It hath these five *Returns*.

Quind. Pasc. A Fornight
Tres. Pasc. Three Weeks } after *Easter*.
Mens. Pasc. A Month
Quinq. Pasc. Five Weeks
Craft. Ascen. The Day after *Holy-Thursday*.

Trinity Term begins the *Friday* after *Trinity-Sunday*, which is next *Sunday* to *Whitsunday*, and hath these four *Returns*.

Craft. Trin. The *Munday* after *Trinity-Sunday*.
Oct. Trin. A Week after *Trinity-Sunday*.
Quind. Trin. A Fornight after *Trinity-Sunday*.
Tres. Trin. Three Weeks after *Trinity-Sunday*.

The *Exchequer* opens four Days before *Trinity-Term*; but eight Days before the other *Terms*.

Lo! here a Trade *surpasseth all the rest*;
No Change *annoys the* Lawyer's Interest.
His Tongue *buyes* Lands, *builds* Houses, *without Toil*;
The Pen's *his* Plough, *the* Parchment *is his* Soil;
Him Storms *disturb not, nor* Militia Bands.
The Tree *roots best, that in the* Weather *stands*.

How to Rectifie the *Tables* of the *Sun's Declination* at any Time by *Prostaphæreses*.

The Use of the Table.

When the Declination increaseth, then add; and for decreasing, substract.

IN this *Kalendar*, Printed for the *Year* 1665, 66, 67, and 1668. the *Sun's Declination* to be trusted sufficient; but for any *Year* after 1668. the *Rule* is thus.

For Example. I would know the *Sun's Declination* for the *Year* 1689. you must always substract 1668. from the *Year* given, which is here 1689. the Remainder is 21 *Years*; which being divided by 4, the *Quotient* is 5 *Leap-Years*, and 1 remains, which sheweth it is the first *Year*.

8 d. 39 m. Declination 1 April 1689.

Now I desire to rectifie the *Table* for the first day of *April*, which in the *Kalendar* you have 8 *deg.* 36 *min.* and in this *Table* you have 40 *Seconds*; which multiplied by 5 *Leap-years*, give 200 *Seconds*, that is 3 *m.* 20 *sec.* to be added to 8 *deg.* 36 *min.* So have you 8 *deg.* 39 *min.* for the *Sun's Declination* in 1689.

Prostaphæreses *of the* Suns Declination.

Day Month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Octob.	Nov.	Dec.
	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.
1	17	36	42	40	28	8	15	33	42	41	30	9
2	18	37	43	39	28	7	15	34	43	42	29	8
3	19	37	43	40	27	6	16	35	43	42	29	7
4	20	38	44	40	27	5	17	35	43	42	28	6
5	20	37	44	39	26	4	18	34	43	41	28	5
6	21	37	43	39	25	4	19	35	43	41	28	4
7	21	38	43	38	25	3	19	35	44	41	27	3
8	22	39	43	38	24	2	19	35	43	40	26	2
9	24	38	44	38	23	2	20	36	44	40	25	1
10	24	39	45	37	23	1	21	36	43	40	24	1
11	25	39	44	37	22	0	21	37	43	40	24	0
12	25	40	44	37	22	1	22	38	43	39	23	0
13	26	41	43	37	21	1	22	38	43	39	22	1
14	26	40	44	37	20	2	23	38	44	38	21	2
15	27	41	44	35	20	3	23	38	43	38	21	3
16	28	42	43	35	19	4	24	39	44	37	20	4
17	28	41	42	35	19	4	25	39	43	38	20	5
18	29	41	43	35	18	5	26	39	43	37	19	6
19	30	41	43	34	17	6	26	39	43	37	18	7
20	31	42	42	34	17	7	27	40	43	36	17	8
21	31	42	43	33	16	8	27	40	43	36	16	9
22	32	42	43	33	15	8	28	41	44	35	16	10
23	32	43	43	32	14	9	29	40	43	35	15	11
24	32	43	42	32	14	10	29	41	42	34	14	12
25	33	44	42	31	12	11	30	41	43	34	13	12
26	33	44	41	30	12	12	30	41	42	33	13	13
27	34	43	41	30	11	13	30	41	42	34	12	14
28	35	43	41	29	9	14	31	41	43	32	11	16
29	35	43	41	29	9	14	31	41	43	32	11	16
30	35		41	29	9	14	32	42	42	32	10	16
31	36		41		8		33			31		17

A Table

A Table *of the* Sun's Declination.

January XXXI.

Day Mo.	Day Week	☌ Epact	Hour.	☉ Rif. ☽ Setting.	Leap-ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	A	29		Circumcif.	21	50		21	43		21	45		21	47	
2	B	28		4 1 8	21	40	10	21	33	10	21	35	10	21	38	9
3	C	26	12	4 2 8	21	30	10	21	22	11	21	25	10	21	28	10
4	D	25	08	4 3 8	21	20	10	21	11	11	21	14	11	21	17	11
5	E	23	21	4 4 8	21	09	11	21	00	11	21	03	11	21	6	11
6	F	*		Twelf day.	20	57	12	20	48	12	20	51	12	20	54	12
7	G	22	10	4 7 8	20	45	12	20	36	12	20	39	12	20	42	12
8	A	21		4 8 8	20	33	12	20	24	12	20	27	12	20	30	12
9	B	20	06	☉ in ♒	20	21	12	20	11	13	20	14	13	20	17	13
10	C	18	18	4 11 8	20	8	12	19	58	13	20	1	13	20	4	13
11	D	*		4 12 8	19	55	13	19	44	14	19	49	14	19	51	13
12	E	17	15	4 14 8	19	41	14	19	30	14	19	33	14	19	37	14
13	F	16		*Hilary.*	19	27	14	19	16	14	19	19	14	19	23	14
14	G	15	03	4 11 8	19	12	15	19	01	15	19	04	15	19	8	15
15	A	*		4 18 8	18	57	15	18	46	15	18	50	14	18	54	14
16	B	14	0	4 20 8	18	42	15	18	31	15	18	35	15	18	39	15
17	C	12	12	4 21 8	18	27	15	18	15	16	18	19	16	18	23	16
18	D	*		4 23 8	18	11	16	17	59	16	18	3	16	18	7	16
19	E	11	1	☉ to ♒	17	55	16	17	42	17	17	47	16	17	51	16
20	F	9	0	*Oct. Hilar.*	17	38	17	17	26	16	17	30	17	17	34	17
21	G	7	10	*Except.*	17	22	16	17	9	17	17	13	17	17	17	17
22	A	*		*Ret. Brev.*	17	5	17	16	51	18	16	56	17	17	00	17
23	B	6	6	Term beg.	16	47	18	16	34	17	16	38	18	16	42	18
24	C	4	18	4 33 8	16	30	17	16	16	18	16	20	18	16	25	17
25	D	*		Conv. Paul	16	12	18	15	58	18	16	2	18	16	7	18
26	E	3	7	4 37 8	15	54	18	15	40	18	15	44	18	15	49	18
27	F	2	0	*Qu. Hilar.*	15	35	19	15	21	19	15	25	19	15	30	19
28	G	1	3	*Except.*	15	16	19	15	2	19	15	7	18	15	11	19
29	A	*		*Ret. Brev.*	14	57	19	14	43	19	15	48	19	14	52	19
30	B	29	16	*Appear.*	14	38	19	14	22	21	14	28	20	14	33	19
31	C	28	12	4 46 8	14	18	20	14	4	28	14	8	20	14	13	20

South Declination. *South Declination.*

A Table *of the* Sun's Declination.

February XXVIII.

Da. Mo.	D. Week	α Epact.	Hour.	☉ Ris. & Setting.	Leap-ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1606 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	D	27		4 18 8	13	59		13	44		13	48		13	53	
2	E	26	1	Purif. Mar.	13	39	20	13	24	20	13	28	20	13	33	20
3	F	25		*Craft. Pur.*	13	10	20	13	3	21	13	8	20	13	13	20
4	G	23	10	*Except.*	12	58	22	12	43	20	12	48	20	12	52	21
5	A	22	22	*Ret. Brev.*	12	38	20	12	22	21	12	27	21	12	32	20
6	B	21		*Appear.*	12	17	21	12	1	21	12	6	21	12	11	21
7	C	20	18	4 59 8	11	56	21	11	40	21	11	45	21	11	50	21
8	D	19		☉ *in* ♓	11	35	21	11	19	21	11	24	21	11	29	21
9	E	18	8	*Oct. Pur.*	11	14	21	10	57	22	11	2	22	11	8	21
10	F	18	18	*Except.*	10	52	22	10	36	21	10	40	22	10	47	21
11	G	17	3	*Ret. Brev.*	10	30	22	10	14	22	10	19	21	10	24	23
12	A	15	16	*Term ends.*	10	8	22	9	52	22	9	57	22	10	2	22
13	B	*		5 11 7	9	46	22	9	30	22	9	35	22	9	40	22
14	C	14	12	Valentine.	9	24	22	9	7	23	9	13	22	9	18	22
15	D	13		5 14 7	9	2	22	8	45	23	8	50	23	8	55	23
16	E	12	1	5 16 7	8	39	23	8	22	22	8	27	23	8	33	22
17	F	11	14	5 18 7	8	17	22	8	0	23	8	5	22	8	11	22
18	G	9	10	☉ 10 ♓	7	54	23	7	37	23	7	42	23	7	44	22
19	A	8		5 22 7	7	31	23	7	14	23	7	20	22	7	26	20
20	B	7	0	5 24 7	7	8	23	6	51	23	6	57	23	7	3	25
21	C	6	19	5 26 7	6	45	23	6	28	24	6	34	23	6	39	24
22	D	5		5 28 7	6	22	23	6	4	23	6	10	24	6	16	23
23	E	4	7	5 30 7	5	59	23	5	41	23	5	47	23	5	53	23
24	F	3	20	Matthew.	5	36	23	5	18	23	5	24	23	5	30	23
25	G	2		5 34 7	5	12	24	4	55	24	5	0	24	5	5	25
26	A	1	16	5 36 7	4	49	23	4	31	23	4	37	23	4	43	22
27	B	*		5 38 7	4	25	24	4	8	24	4	13	24	4	19	24
28	C	29	5	☉ 20 ♓	4	2	23	3	44		3	50	23	3	56	23
					3	39	23									

South Declination. *South Declination.*

A Table

A Table *of the* Sun's Declination.

MARCH XXXI.

						Leap-ye.			*First.*			*Second.*			*Third.*			
						1664			1665			1666			1667			
						1668			1669			1670			1671			
						1672			1673			1674			1675			
						1676			1677			1678			1679			
						1680			1681			1682			1683			
						1684			1685			1686			1687			
						1688			1689			1690			1691			
						1692			1693			1694			1695			
Day Mo	*Da Week*	*Epact*	*Hour.*	☉ *Rif. & Setting.*		*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	
1	D	28	1	David.		3	15		3	20		3	26		3	32		*South Declination.*
2	E	26	14	5	44 7	2	51	24	2	57	23	3	3	23	3	9	23	
3	F	✱		5	46 7	2	28	23	2	33	24	2	29	24	2	45	24	
4	G	25	10	5	48 7	2	4	24	2	9	24	2	16	13	2	21	24	
5	A	24		5	50 7	1	40	24	1	46	23	1	52	24	1	58	23	
6	B	23	0	5	52 7	1	16	24	1	22	24	1	28	24	1	34	24	
7	C	21	11	5	54 7	0	53	23	0	59	23	1	5	23	1	11	23	
8	D	21		5	56 7	0	29	24	0	35	24	0	41	24	0	46	24	
9	E	20	7	5	58 7	0	5	24	0	11	24	0	17	24	0	23	23	
10	F	18	20	☉	*in* ♈	*Nor.*	18	24	*Nor.*	13	24	*North* 6	11		*North* 1	22		*Æquinoctial.*
11	G	✱		6	2 6	0	42	24	0	37	23	0	30	24	0	25	24	
12	A	17	16	6	4 6	1	6	23	0	00	24	0	54	24	0	49	24	
13	B	16		6	6 6	1	29	24	1	24	23	1	18	24	1	12	23	
14	C	15	5	6	8 6	1	53	23	1	47	24	1	42	24	1	36	24	
15	D	14	1	6	10 6	2	16	24	2	11	24	2	5	23	2	00	32	
16	E	12	14	6	12 6	2	40	24	2	35	23	2	29	24	2	23	23	
17	F	✱		6	14 6	3	4	23	2	58	23	2	52	23	2	46	23	
18	G	11	2	6	18 6	3	27	23	3	21	24	3	15	23	3	10	24	
19	A	10		6	16 6	3	50	24	3	45	23	3	39	24	3	33	23	
20	B	9	0	☉	10 ♈	4	14	23	4	8	23	4	2	23	3	56	23	
21	C	7	11	6	22 6	4	37	23	4	31	23	4	25	23	4	19	23	
22	D	✱		6	24 6	5	00	1	4	54	23	4	49	24	4	43	24	
23	E	6	7	6	26 6	5	23	23	5	17	23	5	12	23	5	6	23	
24	F	4	20	6	28 6	5	46	23	5	40	23	5	35	23	5	29	23	
25	G	✱		An. Mar.		6	9	23	6	3	22	5	57	22	5	52	23	
26	A	3	8	6	32 6	6	31	22	6	25	22	6	20	23	6	15	23	
27	B	2		6	34 6	6	54	23	6	48	23	6	42	22	6	37	22	
28	C	1	7	6	36 6	7	16	22	7	11	22	7	5	23	7	0	23	
29	D	29	17	6	38 6	7	38	22	7	33	22	7	28	23	7	22	22	
30	E	28	14	☉	20 ♈	8	1	23	7	55	22	7	50	22	7	45	23	
31	F	27		6	42 6	8	23	22	8	17	22	8	12	22	8	7	22	

South Declination. | *North Declination.* | *North Declination.*

A Table *of the* Sun's Declination.

April XXX.

Da. Mo.	D. Week	☌ Epact.	Hour.	☉ Rise. & Setting.			Leap-ye.			First.			Second.			Third.			
							1664			1665			1666			1667			
							1668			1669			1670			1671			
							1672			1673			1674			1675			
							1676			1677			1678			1679			
							1680			1681			1682			1683			
							1684			1685			1686			1687			
							1688			1689			1690			1691			
							1692			1693			1694			1695			
							Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	
1	G	26	2	6	44	6	8	45		8	39		8	34		8	29		
2	A	25	22	6	46	6	9	7	22	9	1	22	8	56	22	8	51	22	
3	B	24	0	6	48	6	9	29	22	9	23	22	9	18	22	9	13	22	
4	C	23	11	6	50	6	9	50	21	9	44	21	9	39	21	9	34	21	
5	D	*		6	52	6	10	11	21	10	6	22	10	1	22	9	56	22	
6	E	22	0	6	54	6	10	32	21	10	27	21	10	23	21	10	17	21	
7	F	20	20	6	56	6	10	53	21	10	48	21	10	43	22	10	38	21	
8	G	19		6	57	6	11	14	21	11	9	21	11	4	21	10	59	21	
9	A	18	9	6	59	6	11	35	21	11	30	20	11	25	21	11	20	21	
10	B	*		☉	*in*	♌	11	55	20	11	50	20	11	46	21	11	40	20	
11	C	17	5	7	2	5	12	15	20	12	10	20	12	6	20	12	1	21	
12	D	15	6	7	4	5	12	35	20	12	30	20	12	26	20	12	21	20	
13	E	14	14	7	6	5	12	55	20	12	50	20	12	46	20	12	41	20	
14	F	13		7	8	5	13	15	20	13	10	19	13	6	20	13	1	20	
15	G	12	2	7	10	5	13	34	19	13	29	19	13	25	19	13	20	19	
16	A	11	15	7	11	5	13	53	19	13	48	19	13	44	19	13	40	20	
17	B	10		7	13	5	14	12	19	14	7	19	14	3	19	13	59	19	
18	C	9	11	7	15	5	14	31	19	14	26	19	14	22	19	14	18	19	
19	D	8		7	17	5	14	50	19	14	45	18	14	41	19	14	36	18	
20	E	7	0	☉	10	♌	15	8	18	15	3	18	14	59	18	14	55	19	
21	F	6	20	7	29	5	15	26	18	15	21	18	15	17	18	15	13	18	
22	G	5		7	22	5	15	44	17	15	39	17	15	35	18	15	31	18	
23	A	4	9	George.			16	1	17	15	56	18	15	53	18	15	48	17	
24	B	3	21	7	25	5	16	18	17	16	14	17	16	10	17	16	6	18	
25	C	2		Mark.			16	35	17	16	31	16	16	27	17	16	23	17	
26	D	1	18	7	49	5	16	52	17	16	47	18	16	44	17	16	40	17	
27	E	*		7	31	5	17	59	16	17	5	16	17	1	17	16	57	17	
28	F	29	6	7	32	5	17	25	16	17	21	16	17	17	16	17	13	16	
29	G	28	2	7	34	5	17	41	15	17	37	16	17	33	16	17	29	16	
30	A	27		☉	20	♌	17	56	15	17	52	15	17	49	16	17	44	15	

North Declination. North Declination.

A Table

A Table *of the* Sun's Declination.

MAY XXXI.

Day Mo.	Dn. Week	☾ Epact	Hour.	☉ Rif. & Setting.	*Leap-ye.* 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	*First.* 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	*Second.* 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	*Third.* 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	B	*		Ph. & Ja.	18	11		18	8		18	4		18	00	
2	C	25	11	7 39 5	18	26	15	18	23	15	18	19	15	18	15	15
3	D	24		7 40 5	18	41	15	18	37	14	18	34	15	18	30	15
4	E	23		7 42 5	18	55	14	18	52	15	18	48	14	18	45	15
5	F	22	13	7 44 5	19	9	14	19	6	14	19	2	14	18	59	14
6	G	21		7 45 5	19	25	14	19	19	13	19	16	14	19	13	14
7	A	20	9	7 46 5	19	36	14	19	33	14	19	30	14	19	27	14
8	B	18	21	7 47 5	19	49	13	19	46	13	19	43	13	19	40	13
9	C	*		7 49 5	20	2	13	19	59	13	19	56	12	19	53	13
10	D	17	18	☉ *in* ♊	20	14	12	20	11	12	20	8	12	20	5	12
11	E	16		7 50 5	20	26	12	20	24	13	20	20	12	20	18	13
12	F	15	6	7 53 5	20	38	12	20	36	12	20	32	12	20	30	12
13	G	14	2	7 54 5	20	49	11	20	47	11	20	43	12	20	41	11
14	A	12	15	7 55 5	21	00	11	20	57	12	20	55	11	20	52	11
15	B	*		7 56 5	21	11	10	21	9	10	21	6	10	21	3	11
16	C	11	4	7 57 5	21	21	10	21	19	10	21	16	10	21	14	11
17	D	10		7 58 5	21	31	9	21	29	9	21	26	10	21	24	10
18	E	9	0	7 59 5	21	40	10	21	38	9	21	36	9	21	34	10
19	F	7	13	8 0 4	21	50	9	21	47	9	21	45	9	21	43	9
20	G	*		8 1 4	21	59	8	21	56	9	21	54	8	21	52	9
21	A	6	9	☉ 10 ♊	22	7	8	22	5	8	22	2	9	22	1	9
22	B	4	1	8 3 4	22	15	7	22	13	8	22	11	9	22	9	8
23	C	*		8 4 4	22	22	7	22	21	7	22	19	7	22	17	8
24	D	3	10	8 5 4	22	29	7	22	28	7	22	24	7	22	31	7
25	E	2		8 6 4	22	36	7	22	35	6	22	33	7	22	38	7
26	F	1	6	8 7 4	22	43	6	22	41	6	22	40	6	22	45	7
27	G	29	19	8 8 4	22	49	6	22	47	6	22	46	6	22	51	6
28	A	28	15	8 8 4	22	55	5	22	53	5	22	52	5	22	56	5
29	B	27		8 9 4	23	00	5	22	58	5	22	57	5	23	1	5
30	C	26	4	8 10 4	23	5	4	23	3	5	23	2	5	23	6	5
31	D	*		8 10 4	23	9	4	23	8	5	23	7	5			

North Declination. *North Declination.*

A Table *of the* Sun's Declination.

June XXX.

Da. Mo.	D. Week	☊ Epact.	Hour.	☉ Rise. & Setting.	Leap-ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.	North Declination.
1	E	25	0	☉ 20 ♊	23	13		23	12		23	11		23	10		
2	F	23	13	8 11 4	23	17	4	23	16	4	23	15	4	23	14	4	
3	G	*		8 11 4	23	20	3	23	19	3	23	19	4	23	18	4	
4	A	22	1	8 12 4	23	23	2	23	22	3	23	22	3	23	21	3	
5	B	20	21	8 12 4	23	25	2	23	25	3	23	24	2	23	24	3	
6	C	19		8 12 4	23	27	2	23	27	2	23	26	2	23	26	2	
7	D	18	10	8 13 4	23	29	1	23	28	1	23	28	2	23	28	2	
8	E	*		8 13 4	23	30	1	23	29	1	23	29	1	23	29	1	
9	F	17	6	Days at a	23	31	0	23	30	1	23	30	1	23	30	1	
10	G	15	19	stand.	23	31	0	23	31	1	23	31	1	23	31	1	
11	A	14	15	☉ in ♋	23	31	1	23	31	0	23	31	0	23	31	0	
12	B	13		Days	23	30	1	23	31	0	23	31	0	23	31	0	
13	C	12	4	shorten.	23	29	0	23	30	0	23	30	1	23	30	1	
14	D	11	16	8 13 4	23	29	2	23	29	1	23	29	1	23	29	1	
15	E	10		8 13 4	23	27	2	23	27	2	23	28	1	23	28	1	
16	F	9	13	8 12 4	23	25	3	23	25	2	23	26	2	23	26	2	
17	G	8		8 12 4	23	22	3	23	23	2	23	23	3	23	24	2	
18	A	7	1	8 12 4	23	19	3	23	20	3	23	20	3	23	21	3	
19	B	6	21	8 11 4	23	16	4	23	17	4	23	17	3	23	19	2	
20	C	5		8 11 4	23	12	4	23	13	4	23	13	4	23	15	4	
21	D	4	10	8 11 4	23	8	5	23	9	5	23	9	4	23	11	4	
22	E	*		☉ 10 ♋	23	3	5	23	4	4	23	5	4	23	6	5	
23	F	3	0	8 10 4	22	58	5	23	0	5	23	1	4	23	2	4	
24	G	1	19	John Bapt.	22	53	6	22	55	6	22	56	5	22	57	5	
25	A	*		8 8 4	22	47	6	22	49	4	22	51	5	22	51	6	
26	B	29	6	8 8 4	22	41	7	22	43	7	22	45	6	22	45	6	
27	C	28	4	8 7 4	22	34	7	22	36	7	22	38	7	22	39	6	
28	D	26	17	8 6 4	22	27	7	22	24	7	22	31	7	22	33	6	
29	E	*		Peter Ap.	22	20	7	22	22	8	22	34	7	22	26	7	
30	F	25	13	8 4 4	22	12	8	22	14	8	22	16	8	22	18	8	

North Declination.

A Table of the Sun's Declination.

July XXXI.

					Leap-ye.			First.			Second.			Third.		
					1664			1665			1666			1667		
					1668			1669			1670			1671		
					1672			1673			1674			1675		
					1676			1677			1678			1679		
					1680			1681			1682			1683		
					1684			1685			1686			1687		
					1688			1689			1690			1691		
					1692			1693			1694			1695		
Day Mo.	Day Week	Epact	Hour.	☉ Rise. & Setting.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.	Deg.	Min.	Differ.
1	G	24		8 3 4	22	4		22	6		22	8		22	10	
2	A	23	1	☉ 20 ♋	21	56	8	21	58	8	22	00	8	22	2	8
3	B	22	14	8 2 4	21	47	9	21	49	9	21	51	9	21	54	9
4	C	21		8 1 4	21	38	9	21	40	9	21	42	9	21	45	9
5	D	20	10	8 0 4	21	28	10	21	31	10	21	33	9	21	35	10
6	E	19		7 58 5	21	18	10	21	21	10	21	23	10	21	26	9
7	F	18	0	7 57 5	21	8	10	21	11	11	21	13	10	21	16	10
8	G	17	19	7 56 5	20	57	11	21	00	11	21	3	10	21	5	11
9	A	16		7 55 5	20	46	11	20	49	12	20	52	11	20	54	11
10	B	15	8	7 54 5	20	34	12	20	37	11	20	40	12	20	43	11
11	C	14	4	7 53 5	20	23	11	20	26	12	20	29	11	20	31	12
12	D	12	17	7 52 5	20	11	12	20	14	12	20	17	12	20	20	11
13	E	*		☉ *in* ♌	19	59	12	20	2	13	20	5	12	20	8	12
14	F	11	5	7 49 5	19	46	13	19	49	13	19	52	13	19	55	13
15	G	10		Swithin.	19	33	13	19	36	13	19	39	13	19	42	13
16	A	9	1	7 46 5	19	20	13	19	23	13	19	26	13	19	24	13
17	B	7	14	7 45 5	19	6	14	19	10	14	19	13	13	19	16	13
18	C	*		7 43 5	18	52	14	18	56	14	18	59	14	19	2	14
19	D	6	10	*Dog d. beg.*	18	30	14	18	42	15	18	45	14	18	48	14
20	E	5		7 40 5	18	23	15	18	27	15	18	30	15	18	34	14
21	F	4	0	7 39 5	18	8	15	18	12	15	18	15	15	18	19	15
22	G	3	11	Magdalen.	17	53	15	17	57	16	18	00	15	18	4	15
23	A	2		☉ 10 ♌	17	37	16	17	41	16	17	45	15	17	49	15
24	B	1	8	7 34 4	17	21	16	17	25	16	17	29	16	17	23	16
25	C	29	20	S. Jam. Ap.	17	5	16	17	9	16	17	13	16	17	17	16
26	D	28	14	7 0 5	16	49	16	16	53	16	16	57	16	17	1	16
27	E	27		7 29 5	16	33	16	16	37	17	16	41	16	16	45	16
28	F	26	5	7 27 5	16	16	17	16	20	17	16	24	17	16	28	17
29	G	*		7 25 5	15	59	17	16	3	18	16	7	17	16	11	17
30	A	25	1	7 24 5	15	41	18	15	45	18	15	50	17	15	54	17
31	B	23	14	7 22 5	15	23	18	15	27	18	15	33	18	15	36	18

North Declination. North Declination.

A Table *of the* Sun's Declination.

August XXXI.

						Leap-yr.			*First.*			*Second.*			*Third.*		
						1664			1665			1666			1667		
						1668			1669			1670			1671		
						1672			1673			1674			1675		
						1676			1677			1678			1679		
						1680			1681			1682			1683		
						1684			1685			1686			1687		
						1688			1689			1690			1691		
						1692			1693			1694			1695		
Da. Mo.	*D. Week.*	*K Epact.*	*Hour.*	*⊙ Rif. & Setting.*		*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	C	*		Lamas.		15	5		15	10		15	14		15	19	
2	D	22	3	7	19 5	14	47	18	14	52	18	14	56	18	15	1	18
3	E	21	0	⊙	20 ♌	14	29	18	14	34	18	14	38	18	14	42	19
4	F	20	0	7	16 5	14	10	19	14	15	19	14	19	19	14	24	18
5	G	18	12	7	14 5	13	51	19	13	56	19	14	00	19	14	5	19
6	A	*		7	12 5	13	32	19	13	37	19	13	41	19	13	46	19
7	B	17	8	7	10 5	13	13	19	13	18	19	13	52	19	13	27	19
8	C	15	20	7	8 5	12	54	19	12	59	19	13	3	19	13	08	19
9	D	14	17	7	7 5	12	34	20	12	39	20	12	43	20	12	48	20
10	E	13		Laurence.		12	14	20	12	19	20	12	23	20	12	28	20
11	F	12	5	7	3 5	11	54	20	11	59	20	12	3	20	12	8	20
12	G	11	18	7	1 5	11	33	21	11	38	21	11	43	20	11	48	20
13	A	10		⊙	*in* ♍	11	13	20	11	18	21	11	23	20	11	28	20
14	B	9	14	6	58 6	10	52	21	10	57	21	11	3	20	11	7	21
15	C	8		6	56 6	10	32	20	10	36	21	11	42	21	10	47	20
16	D	7	3	6	54 6	10	11	21	10	15	21	10	21	21	10	26	21
17	E	*		6	52 6	9	50	21	9	54	21	10	00	21	10	5	21
18	F	6	0	6	50 6	9	28	22	9	33	21	9	38	22	9	44	21
19	G	4	12	6	48 6	9	6	22	9	12	22	9	17	21	9	22	22
20	A	*		6	46 6	8	44	21	8	50	21	9	55	22	9	1	21
21	B	3	0	6	44 6	8	23	22	8	29	22	8	33	22	8	39	22
22	C	1	20	6	42 6	8	1	22	8	7	22	8	12	21	8	17	22
23	D	*		⊙	10 ♍	7	39	22	7	45	22	7	50	22	7	55	22
24	E	29	9	Barthol.		7	17	22	7	23	23	7	28	22	7	33	22
25	F	28	5	6	36 6	6	56	23	7	00	23	7	5	23	7	11	22
26	G	26	18	6	34 6	6	32	22	6	38	22	6	43	22	6	45	23
27	A	*		6	32 6	6	10	23	6	15	23	6	21	22	6	26	22
28	B	25	14	*Dog d. end.*		5	47	22	5	53	22	6	58	23	6	4	22
29	C	24	6	6	29 6	5	25	23	5	30	23	5	35	23	5	41	23
30	D	23	3	6	27 6	5	2		5	8	22	5	13	22	5	18	23
31	E	23	15	6	25 6	4	39	27	4	44	24	4	50	23	4	55	23

North Declination. *North Declination.*

A Table

A Table *of the* Sun's Declination.

September XXX.

Day. Mo.	Da. Week	☾ Epact	Hour.	☉ Rif. & Setting.	Leap-ye. 1664 Deg.	Min.	Differ.	First. 1665 Deg.	Min.	Differ.	Second. 1666 Deg.	Min.	Differ.	Third. 1667 Deg.	Min.	Differ.	
1	F	21		Giles.	4	16		4	22		4	27		4	32		
2	G	20	12	6 21 6	3	53	23	3	59	23	4	4	23	4	9	23	
3	A	19		☉ 20 ♍	3	30	23	3	35	24	3	41	23	3	46	23	
4	B	18	0	6 17 6	3	7	23	3	12	23	3	17	24	3	23	23	
5	C	17	20	6 15 6	2	43	24	2	49	23	2	54	23	3	00	23	
6	D	16		6 13 6	2	20	23	2	26	23	2	31	23	2	37	23	
7	E	15	9	6 12 6	1	57	23	2	3	23	2	8	23	2	13	24	
8	F	14	6	Lady Fair.	1	33	24	1	39	24	1	45	23	1	50	23	
9	G	12	18	6 7 6	1	10	23	1	16	23	1	21	24	1	27	23	
10	A	*		6 5 6	0	46	24	0	52	24	0	58	23	1	3	24	
11	B	11	7	6 3 6	0	23	23	0	29	23	0	30	24	0	40	24	
12	C	10		6 1 6	0	1	22	0	5	24	0	10	24	0	16	24	
13	D	9	3	☉ *in* ♎	*South*	24	23	*South*	18	24	*South*	13	7	*South*	7	9	*Æquinctial.*
14	E	7	16	5 57 7	0	48	24	0	42	23	0	36	23	0	31	24	
15	F	*		5 55 7	1	11	23	1	5	24	1	00	23	0	54	23	
16	G	6	12	5 53 7	1	35	24	1	29	24	1	23	23	1	18	24	
17	A	5		5 51 7	1	58	23	1	52	23	1	47	24	1	41	23	
18	B	4		5 49 7	2	22	24	2	16	24	2	10	23	2	5	24	
19	C	3		5 47 7	2	45	23	2	40	24	2	34	24	2	28	23	
20	D	2		5 45 7	3	9	24	3	3	23	2	57	23	2	52	24	
21	E	1	9	Matth. Ap.	3	32	23	3	27	24	3	21	24	3	15	23	
22	F	29	22	5 42 7	3	56	24	3	50	23	3	44	23	3	38	23	
23	G	28	18	☉ 10 ♎	4	19	23	4	13	23	4	7	23	4	2	24	
24	A	27		5 38 7	4	42	24	4	36	23	4	30	23	4	25	23	
25	B	26	17	5 36 7	5	06	23	4	59	23	4	54	24	4	48	23	
26	C	*		5 34 7	5	29	23	5	23	24	5	17	23	5	12	24	
27	D	25	3	5 32 7	5	52	23	5	36	23	5	41	24	5	35	23	
28	E	23	16	5 30 7	6	15	23	6	09	23	6	4	23	5	58	23	
29	F	*		Michael.	6	38	23	6	32	23	6	16	22	6	21	23	
30	G	22	4	5 26 7	7	01	23	6	55		6	49	23	6	44	23	

North Declination. | *South Declination.* | *North Declination.* | *South Declination.*

A Table

A Table *of the* Sun's Declination.

October XXXI.

Da. Mo.	D. Week.	Epact.	Hour.	☉ Ris. & Setting.	Leap-ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	A	21		5 24 7	7	24		7	17		7	12		7	06	
2	B	20	0	5 22 7	7	46	22	7	40	23	7	35	22	7	29	23
3	C	18	13	☉ 20 ♏	8	9	23	8	2	22	7	58	23	7	52	23
4	D	*		5 18 7	8	31	22	8	25	23	8	20	22	8	15	23
5	E	17	9	5 16 7	8	53	22	8	47	22	8	42	22	8	37	22
6	F	22	22	5 14 7	9	15	22	9	9	22	9	4	22	8	59	22
7	G	14	18	5 12 7	9	37	22	9	32	23	9	27	23	9	21	22
8	A	13		5 10 7	9	59	22	9	54	22	9	49	22	9	43	22
9	B	12	7	5 8 7	10	21	22	10	16	22	10	10	21	10	5	22
10	C	11	19	5 6 7	10	43	22	10	37	21	10	32	22	10	27	22
11	D	10		5 4 7	11	04	21	10	59	22	10	53	21	10	48	21
12	E	9	16	5 2 7	11	25	21	11	20	21	11	15	22	11	10	22
13	F	8		☉ *in* ♍	11	46	21	11	41	21	11	36	21	11	31	21
14	G	7	4	4 59 8	12	7	21	12	2	21	11	57	21	11	52	21
15	A	*		4 57 8	12	28	21	12	23	21	12	18	21	12	13	21
16	B	6	0	4 55 8	12	48	20	12	44	21	12	39	21	12	34	21
17	C	4	♎	4 53 8	13	9	21	13	4	20	12	59	20	12	54	20
18	D	*		Luke.	13	29	20	13	24	20	13	20	21	13	14	20
19	E	3	1	4 49 8	13	49	20	13	44	20	13	40	20	13	34	20
20	F	2		*Tres. Mic.*	14	9	20	14	4	20	13	59	19	13	54	20
21	G	1	0	*Except.*	14	28	19	14	24	20	14	19	20	14	14	20
22	A	29	11	*Ret. Brev.*	14	48	20	14	43	19	14	38	19	14	34	20
23	B	28	7	*Term beg.*	15	7	19	15	2	19	14	57	19	14	53	19
24	C	26	19	4 40 8	15	26	19	15	21	19	15	16	19	15	12	19
25	D	*		Crispin.	15	44	18	15	40	19	15	35	19	15	31	19
26	E	25	16	☉ 13 ♍	16	2	18	15	58	18	15	53	18	15	49	18
27	F	24		*Mens. Mi.*	16	20	18	16	16	18	16	11	18	16	7	18
28	G	23	4	Sim. Jude.	16	38	17	16	33	17	16	29	18	16	25	18
29	A	22	17	*Ret. Brev.*	16	55	17	16	51	18	16	47	18	16	32	17
30	B	21		*Appear.*	17	12	17	17	8	17	17	4	17	17	00	18
31	C	20	13	4 2 8	17	29	17	17	25	17	17	21	17	17	17	17

South Declination. South Declination.

A Table *of the* Sun's Declination.

November XXX.

					Leap-ye.			*First.*			*Second.*			*Third.*		
					1664			1665			1666			1667		
					1668			1669			1670			1671		
					1672			1673			1674			1675		
					1676			1677			1678			1679		
					1680			1681			1682			1683		
					1684			1685			1686			1687		
					1688			1689			1690			1691		
					1692			1693			1694			1695		
Da. Mo.	*D. Wk.*	*Epact.*	*Hour.*	☉ *Ris. & Setting.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	D	19		All Saints.	17	46		17	41		17	38		17	32	
2	E	18	2	All Souls.	18	2	16	17	58	17	17	54	16	17	50	17
3	F	*		*Craſt. An.*	18	18	16	18	14	16	18	10	16	18	6	16
4	G	17	0	*Except.*	18	33	15	18	30	16	18	26	16	18	22	16
5	A	15	11	PowderTr.	18	48	15	18	45	15	18	41	15	18	37	15
6	B	14	7	*Appear.*	19	3	15	19	00	15	18	56	15	18	53	16
7	C	12	19	4 16 8	19	18	15	19	14	15	19	11	15	19	8	15
8	D	*		☉ 25 ♏	19	32	14	19	29	14	19	25	14	19	22	14
9	E	11	8	4 15 8	19	46	14	19	43	14	19	39	14	19	36	14
10	F	8		4 13 8	19	59	13	19	56	13	19	53	14	19	50	14
11	G	9	4	Martin.	20	13	14	20	10	14	20	6	13	20	3	13
12	A	7	17	*Craſt. Ma.*	20	26	13	20	23	13	20	19	13	20	16	13
13	B	*		*Except.*	20	38	12	20	35	12	20	31	12	20	29	13
14	C	6	13	*Ret. Brev.*	20	50	12	20	47	12	20	43	12	20	41	12
15	D	5		*Appear.*	20	2	10	20	59	12	20	55	12	20	53	12
16	E	4	2	☉ 4 ♐	21	13	11	21	10	11	21	7	12	21	5	12
17	F	3	14	4 3 8	21	23	10	21	21	11	21	18	11	21	16	11
18	G	2		*Oct. Mar.*	21	34	11	21	31	10	21	29	11	21	26	10
19	A	1	11	*Except.*	21	44	10	21	41	10	21	39	10	21	36	10
20	B	29	23	*Ret. Brev.*	21	54	10	21	51	10	21	49	10	21	46	10
21	C	28	20	*Appear.*	22	3	9	22	00	9	21	58	9	21	56	10
22	D	27		☉ 10 ♐	22	11	8	22	09	9	21	7	9	22	5	9
23	E	26	8	3 56 9	22	20	9	22	18	9	22	16	9	22	13	8
24	F	*		3 55 9	22	28	8	22	26	8	22	24	8	22	22	9
25	G	25	4	*Qu. Mar.*	22	35	7	22	34	8	22	31	7	22	30	8
26	A	23	17	*Except.*	22	42	7	22	41	7	22	39	8	22	37	7
27	B	*		*Ret. Brev.*	22	48	6	22	48	7	22	45	6	22	44	7
28	C	22	6	*Term ends.*	22	54	6	22	54	6	22	52	7	22	50	6
29	D	21		3 51 9	23	00	6	22	59	5	22	58	6	22	56	6
30	E	20	2	Andrew.	23	05	5	23	4	5	23	03	5	23	2	6

South Declination. *South Declination.*

A Table *of the* Sun's Declination.

DECEMBER XXXI.

					Leap ye.		*First.*		*Second.*		*Third.*		
					1664		1665		1666		1667		
					1668		1669		1670		1671		
					1672		1673		1674		1675		
					1676		1677		1678		1679		
					1680		1681		1682		1683		
					1684		1685		1686		1687		
					1688		1689		1690		1691		
					1692		1693		1694		1695		
Day Mo	*Da. Week*	*☾ Epact*	*Hour.*	☉ *Rif.* ☽ *Setting.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*
1	F	18	15	☉ 20 ♑	23	10		23	09		23	08		23	06		
2	G	*		3 50 9	23	14	6	23	13	4	23	12	4	23	11	5	
3	A	17	11	3 49 9	23	18	4	23	17	4	23	16	4	23	15	4	
4	B	15	23	3 48 9	23	21	3	23	20	3	23	20	4	23	19	4	
5	C	14	20	3 48 9	23	24	3	23	23	3	23	23	3	23	22	3	
6	D	13		3 48 9	23	26	2	23	26	3	23	25	3	23	25	3	
7	E	12	8	3 47 9	23	28	2	23	28	2	23	27	2	23	27	2	
8	F	11	21	*Days are*	23	30	2	23	29	1	22	29	2	23	28	1	
9	G	10		*at a ſtand.*	23	31	1	23	30	1	23	30	1	23	30	2	
10	A	9	17		23	31	0	23	31	1	23	31	1	23	31	1	
11	B	8		☉ in ♈	23	31	0	23	31	0	23	31	0	23	31	0	
12	C	7	6	*Days in-*	23	30	1	23	31	0	23	31	0	23	31	0	
13	D	*		*creaſe.*	23	29	1	23	30	1	23	30	1	23	30	1	
14	E	6	2	3 47 9	23	28	1	23	29	2	23	29	1	23	29	1	
15	F	4	15	3 47 9	23	26	2	23	27	2	23	27	2	23	27	2	
16	G	*		3 48 9	23	24	2	23	25	2	23	25	2	23	25	2	
17	A	3	3	3 48 9	23	21	3	23	22	3	23	22	3	23	23	2	
18	B	2		3 49 9	23	18	3	23	19	3	23	19	3	23	20	3	
19	C	1	0	3 49 9	23	14	4	23	15	4	23	16	4	23	16	4	
20	D	29	12	☉ 9 ♈	23	9	5	23	10	5	23	12	4	23	12	4	
21	E	28	8	Thomas.	23	5	4	23	6	6	23	7	5	23	8	5	
22	F	27		3 50 9	23	00	5	23	1	6	23	2	5	23	3	5	
23	G	26		3 51 9	22	54	6	22	55	6	23	57	5	22	54	5	
24	A	25	17	3 52 9	22	48	6	22	49	7	23	51	6	22	52	6	
25	B	24		Chriſtmas.	22	41	7	22	43	8	22	45	6	22	46	6	
26	C	23	6	Stephen.	22	34	7	22	36	8	22	38	7	22	39	7	
27	D	22	18	John.	22	27	7	22	21	8	22	31	7	22	32	7	
28	E	21		Innocents.	22	19	8	22	20	8	22	23	8	22	25	7	
29	F	20	15	3 56 9	22	11	8	22	12	8	22	15	8	22	17	8	
30	G	19		3 57 9	22	9	8	22	4	9	22	6	9	22	8	9	
31	A	18	3	3 58 9	21	53	6	21	55	9	21	57	9	21	59	9	

South Declination. *South Declination.*

To find the Sun's Declination *upon every* Day *of the* Year.

THE *Sun's Year* (that is, the time that the *Sun* goeth out of a certain *Point* of the *Ecliptick*, and returneth again to the ſame) is not of 365 *days* juſt; but about 5 *Hours* and 49 *Minutes* more (that is, little leſs than 6 *Hours*;) Wherefore after three *Years*, there is always added to the fourth four times 6 *Hours*, that is, a *Day* more in *February*, for to count the *Year* or the *Revolution* of the *Sun* in even *Days*; therefore that fourth *Year* is called *Leap-year*: Therefore when we deſcribe the *Sun's Declination* in *Tables*, we always uſe to make four ſeveral *Tables*, for four ſuch *Years* following one the other; and yet by reaſon of the foreſaid difference, that four *Revolutions* of the *Sun* do not juſtly make up one *Day*, but wants about 48 *min.* bringeth in proceſs of time ſo great a difference in the *Declination*, that it is needful every twenty *Years* to renew ſuch *Tables*.

How to find the *Leap-years*, it is thus: Divide the *Year* of our *Lord* above 1600. by 4; If the *Diviſion* doth fall out even, without any *over-plus*, that *Year* then is a *Leap-year* of 366 *Days*: But if out of the *Diviſion* there remain any *Number*, that *Remainder* ſheweth how many *Years* that *Year* propounded, is after the *Leap-year*.

For EXAMPLE.

I deſire to know what *Year* the *Year* 1666. is. Leaving 1600, I divide 66 by 4, and find there remains 2; for 16 times 4, or 4 times 16, is 64; that taken from 66, there remains 2; whereby I find the *Year* 1666. to be the ſecond *Year* after the *Leap-year*. In the like manner you muſt work for any other *Years*: Only note this, If nothing remaineth upon the *Diviſion* out of the *Quotient*, then it is a *Leap-year* if it be even.

As for EXAMPLE.

It is required to know what *Year* 1692 is. Leaving the 1600, divide the 92 by 4, and nothing remains upon the *Diviſion*, but is even 23 in the *Quotient*; whereby I find that *Year* 1692. is a *Leap-year*.

For to know the ſame by the foregoing *Tables*, it is thus. Each *Month* hath 12 *Columns*; The firſt thereof ſhews the *Days* of the *Month*; The ſecond *Column*, having the *Dominical Letters*, ſhews the *Days* of the *Week*; The third *Column* having two Rows of *Figures*, the firſt of them ſhews the *Epact* of the *Moon*, and the other the *Hour* of the *Day*, reckoning the ſaid *Hours* always from *Noon*; the fourth *Column* ſhews the Chief *Days* of the *Year*, and the *Terms* and their *Returns* which are fixed and certain; and in the void places it ſhews the *Riſing* and *Setting* of the *Sun* in this *Latitude*, and the Place of the *Sun* every 10 *Day* or *Degree*. Theſe four *Columns* of themſelves are fit for Mens ordinary uſe, and may be made with a little Art and Pains to perform all the *Concluſions* which the yearly *Almanacks* ſhew and teach, as you ſhall ſee by the following *Rules* and *Obſervations*.

The fifth *Column* of the foregoing *Tables* ſhews the *Sun's Declination* for every *Day* of the *Year*, for all theſe *Years* in the firſt *Column* under-written, which are all *Leap-years*. The ſixth *Column* ſhews the *Daily Difference* of the *Sun's Declination*. The ſeventh *Column* ſhews the firſt *Year* from the *Leap-year*: The eighth, the *Daily Difference* of the *Sun's Declination* in that *Year*. The ninth ſhews the ſecond *Year* from the *Leap-year*; The tenth, the *Difference*; The eleventh, the third *Year* from the *Leap-year*; The twelfth, the *Difference* every *Day* of the *Sun's Declination*, as you ſee in the *Tables*. This *Table* following ſhews the *Leap years*, *Firſt*, *Second*, and *Third Years*, as they are plainly expreſſed in the Head of each *Table*.

Leap-years.	*First.*	*Second.*	*Third.*
1664	1665	1666	1667
1668	1669	1670	1671
1672	1673	1674	1675
1676	1677	1678	1679
1680	1681	1682	1683
1684	1685	1686	1687
1688	1689	1690	1691
1692	1693	1694	1695

For to find the *Sun's Declination*, Look for the *Day* of the *Month* in the left hand of the *Table*, and in the common *Angle* of meeting you will find the *Declination* which you seek after.

I. *EXAMPLE.*

I desire to know the *Sun's Declination* for the 22 of *May*, in the *Year* 1693. being the first *Year* after the *Leap-year*. In the Head of the *Table* I find the *Month* and *Year*; on the left hand of the *Table* I find the *Day*; and in the *Common Angle* or *Line* of *Meeting*, I find the *Declination* I look for to be *North* 22 *deg.* 13 *min.*

II. *EXAMPLE.*

Upon the 5th of *November* in the *Leap-year* 1692. I desire to know the *Declination* of the *Sun*. In the Head of the *Table* I find the *Month* and *Day*, and in the first *Column* to the left hand I find the *Day* of the *Month*, and in the *Common Line* of *Meeting*, under the *Year*, I find the *Sun's Declination* required, to be 18 *deg.* 37 *m. South Declination*; and his *Difference* in 24 *Hours*, 15 *min.*

The foregoing *Tables* of the *Sun's Declination* is rectified properly for the *Meridian* of the most famous and *Metropolitan* City of *London*. The *Constant Kalendar* I borrowed out of Ingenious Mr. *Philips's Purchaser's Pattern*, at the end of *page* 247. With some addition it is very useful with the foregoing *Tables*.

A Table *by which you may proportion the* Sun's Declination *to any other* Meridian.

The Difference in Declination *daily.*		*M* 00	*M* 03	*M* 06	*M* 09	*M* 12	*M* 15	*M* 18	*M* 21	*M* 24
		M	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*
	Deg. 15	0	0	0	0	0	0	1	1	1
	30	0	0	0	0	1	1	1	2	2
	45	0	0	0	1	1	2	2	3	3
Degrees *of*	60	0	0	1	1	2	2	3	3	4
Difference of	75	0	0	1	2	2	3	4	4	5
Longitude	90	0	0	1	2	3	4	4	5	6
either East *or*	105	0	1	2	2	3	4	5	6	7
West.	120	0	1	2	3	4	5	6	7	8
	135	0	1	2	3	4	5	7	8	9
	150	0	1	2	3	5	6	8	9	10
	165	0	1	2	4	5	6	8	10	11
	180	0	1	2	4	6	7	9	11	12

Of the Difference *and* Æquation *of* Declination *in divers Places of the* Earth.

NOte this, They that are more *Easterly* from the *Meridian* of *London*, have the *Declination* less when the *Sun* declineth from the *Line*, and increaseth in *Declination* either *Northward* or *Southward*, as well between the 10th of *March* and the 12th of *June*, as between the 13th of *September* and the 12th of *December*; and more when the *Sun* returneth again towards the *Line*, whether it be *North* or *South* of the *Line*, as well between the 12th of *December* and the 10th of *March*, as between the 12th of *June* and the 13th of *September*.

On

On the contrary, They that are more *Westerly* from the *Meridian* of *London*, when the *Declination* increaseth *North* or *South*, have more *Declination*, and less when the *Declination* decreaseth; that is, when the *Sun* is going towards the *Æquinoctial*, either on the *North* or *South* side of the *Line*; the reason is, because the *Sun* cometh to the *Meridian Eastward*, to them that live there, always before it doth to us; and them that live more *Westerly*, have him later to their *Meridian*.

EXAMPLE I.

Of those that are more Easterly, *which increase in* Declination.

On the 26th of *March*, the first *Year* after the *Leap-year*, I desire to know the *Declination* of the *Sun* at *Noon* at *Bantam* in the *East-Indies*. I find by *Globes*, or the *Plat* of *Mercator*, that *Bantam* is to the *Eastward* of the *Meridian* of *London* about 110 *Degrees*; we do not esteem of a *Degree* or two, because it amounteth to nothing in this *Practice*. The *Sun* for his *Course* round the *Heavens* and *Earth*, which is 360 *Degrees*, hath need of 24 *Hours*; What time will 110 *Degrees* have? *Facit* 7 *Hours*, and something more not worth the noting; whereby the *Sun* comes to the *Meridian* 7 *Hours* sooner at *Bantam*, than it doth at *London*; That it is 12 a Clock at *Noon* at *Bantam*, when it is 4 of the Clock in the *Morning* with us at *London*. The *Sun's Declination* for the 26th of *March*, is 6 *deg.* 25 *min.*: The *Difference* of the *Declination* of the *Day* following, you find is 23 *min.* which it is increased; Therefore I say, If in 24 *Hours* the *Declination* increaseth 23 *Minutes*, How much then in 7 *Hours*? *Facit* almost 7 *Minutes*, that the *Declination* is less than it is at *London*. So that the *Declination* at *Bantam* that *Day*, is but 6 *deg.* 18 *min. North*: And on the contrary, when the *Declination* decreaseth, work, and you will have the *Declination South*, *Eastward*, or *Westward*.

360. 24. 110
24
440
220
(1 2640
3(2
264(0 (7
36(0

161
24. 23. 7/8
7
161
(1
4(7
161 (6
24

EXAMPLE II.

The Use of the Table.

On the 17th of *September* in the same *Year*, I desire to know the *Declination* that day at *Noon* at *Bantam*. The *Declination* for the *Meridian* of *London* is that *Day* 1 *deg.* 52 *min.* and the *Difference* of the *Declination* of the *Day* following is 24 *min.* decreased; and, as was said before in the last *Example*, the difference of *Longitude* is 110 *deg.* Therefore I look in the Head of the foregoing *Table*, for the nearest *Number* to the *Difference* 24, and find it to fall just even on the Head of the last *Column*; then look on the left hand of the *Table* for the *Difference* of *Longitude*, and I find 105 *deg.* nearest, and in the *Common Angle* of *Meeting* I find 7, which is to be substracted from the *Declination* in the *Meridian* of *London* aforesaid, 1 *deg.* 52 *min.* and the *Remainder* will be the *Declination* for the *Meridian* or *Longitude* I am in, which is 1 *deg.* 45 *min. South*: But if the *Declination* decreaseth, as it doth here increase, then you must have added.

	deg.	*min.*
In the Meridian *of* London *the* Declination	01	52
The Minutes Proportional *substracted*	00	07
The Declination *for* 110 deg. Longitude *of* Bantam, East	01	45
The Declination *of* 110 deg. West *of the* Meridian *of* London	00	07
West	01	52

EXAMPLE

EXAMPLE III.

A *Ship* coming on the ſeventh of *November*, in the third *Year* after the *Leap year*, into the great *South-Sea*, thwart of the *Coaſt* of *Peru*, in *Longitude* 76 *deg.* The *Pilot* deſireth the *Declination* there at *Noon* in that *Meridian.*

	deg.	*min.*	
In the Meridian *of* London *the* Declination *is*	19	08	*South.*
The Minutes Proportional *added*	00	03	
In the Longitude 76 deg. *the* Declination	19	11	*Weſt.*
In the Longitude *of* 76 deg. Eaſt, *the* Declination *is*	19	05	

Two *Ships* being in Company, they parted at the *Lands end* of *England*: The one Sails *Eaſtwards*, and cometh upon his *Reckoning* upon the 28th of *September* 180 *Degrees* on the other ſide the *Globe* of the *Earth* (being the firſt *Year* after the *Leap-year*) and by the foregoing *Tables* finds the *Sun's Declination* 5 *deg.* 57 *min.* The other *Ship* Sails *Weſtwards*, and meeteth the firſt *Ship* at the aforeſaid place, by his Reckoning not the 28th, but on the 27th of *September*, and findeth the *Declination* in theſe *Tables* for that *Day*; ſo that they differ in the *Time* one *Day*, and in *Declination* 24 *min.* the which proceedeth from this cauſe: The firſt having Sailed againſt the *Riſing* of the *Sun* 180 *Degrees*, hath ſhortned his time 12 *Hours*; the other hath Sailed with the *Sun* 180 *Degrees*, hath lengthned his time 12 *Hours*, and thereby hath one *Night* leſs than the firſt. Seeing then in 24 *Hours* increaſeth 24 *Minutes*, he that Sailed *Eaſtward* muſt reckon 12 *Minutes Declination* leſs, and he that Sailed *Weſtward* 12 *Minutes* more than the *Table* doth ſhew; and ſo both of them ſhall keep one manner of *Declination*, to wit, 6 *deg.* 9 *min.*

A Table *of the* Refractions *of the* Sun, Moon, *and* Stars, *according to the Obſervation of thrice Noble* Tycho Brahe.

Alti-tudes.	*Sun.* *min.*	*Moon* *min.*	*Stars* *min.*	*Alti-tudes.*	*Sun.* *min.*	*Moon* *min.*
0	34	33	30	18	06	06
1	26	25	21	19	05	06
2	20	20	15	20	04	05
3	17	17	12	21	04	05
4	15	15	11	22	03	04
5	14	14	10	23	03	04
6	13	13	00	24	03	04
7	12	13	08	25	02	03
8	11	12	07	26	02	03
9	10	11	06	27	02	03
10	10	11	05	28	02	02
11	09	10	05	29	02	02
12	09	09	04	30	01	02
13	08	00	04	31	01	02
14	08	08	03	32	01	01
15	07	08	03	33	01	01
16	07	07	02	34	01	01
17	06	07	02	35	01	01

THe *Refraction* of the *Sun*, *Moon* and *Stars*, cauſeth them to appear higher above the *Horizon* than they are: Therefore the *Refraction* is alway to be ſubſtracted from the *Altitude* obſerved, that the true *Altitude* may be had.

As for Example.

The *Sun's Meridian Altitude* by Obſervation being 9 *Degrees*, I require the true *Altitude.*

	deg.	*mi.*
Altitude *by Obſervation*	9	00
Refraction *ſubſtract*	0	10
The true Meridian Altitude	8	50

Of the *Refraction* of the *Sun*, A *Dutch Ship* being upon the Diſcovery of a *North-Eaſt* Paſſage to the *Eaſt-India*, was forced to Winter in *Nova Zembla*: the *Mariners* beheld the *Sun* 14 *days* ſooner than he ſhould by his *Declination*, and by Computation 5 *Degrees* under the *Horizon*; which is cauſed by the groſs *Vapours*, and thickneſs of the *Air* neer the *Horizon.*

THE

The USE of the CONSTANT KALENDAR.

I. *To know the* Day *of the* Month.

THis is the Chief and moſt uſeful *Obſervation* of any *Almanack*, and may as well be performed by this, as by any other. To this purpoſe, you muſt by the general *Kalendar* at the beginning hereof, know the *Dominical* or *Sunday Letter* for the *Year*; then conſidering with your ſelf, whether it be the beginning, midſt, or end of the *Month* (as you muſt do in any *Almanack*) find this *Letter* in the beginning, midſt, or end of the *Month*, and reckoning from it to the *Day* of the *Week*, either *Munday*, or *Tueſday*, or whatſoever other *Day* it is, right againſt the *Day* of the *Week*, you ſhall find what *Day* of the *Month* it is. Here is no difficulty in this; only when it is *Leap-year* you ſee there is two *Sunday Letters*, the firſt of theſe you may uſe only to the 24th of *February*, and the other all the *Year* after.

For Example. In the 1668. the *Dominical Letter* E D the firſt *Sunday* in *January*, is at the firſt E, which is at the fifth *Day* of the *Month*; the firſt *Sunday* in *February* is at the ſecond *Day* of the *Month*; but the firſt *Sunday* in *March* is at the firſt D, which is at the firſt *Day* of the *Month*, and ſo all the *Year* after.

II. *To know what* Day *of the* Week *any* Notable Day *will fall upon, in any* Year.

Firſt find the *Dominical Letter* in the former *Table*; then find your *Letter* in your *Month* next before the *Day* you deſire, and ſo from thence count the *Days* of the *Week*, till you come to the *Day* deſired. Thus if you would know what *Day* of the *Week* *Lady-day*, or the *Annunciation* of the *Lady Mary* falls upon this *Year* 1668. the *Dominical Letter* is D; this is three *Days* before the ſaid *Day*, therefore that falls upon a *Wedneſday*.

But now in the *Year* 1669. when the *Dominical Letter* is C, *Lady-day* will be upon the *Thurſday*. This will be in a ſhort time as ready to you, as if theſe *Letters* were painted out for you in *Vermilion*.

III. *To find the Time of* Sun Riſing *and* Setting.

This is ſet down for moſt of the *Days* in the whole *Year*, for *London*; and may ſerve for all the *Eaſt*, *South*, and *Weſt Parts* of *England*: And this is done after ſomewhat a briefer manner than is uſual, making the *Minutes* which are placed in the midſt, to ſerve both the *Hours* of *Setting* and *Riſing*; which you muſt underſtand thus: The 7th of *February* you ſhall find theſe *Figures*, 4. 59. 8. that is, the *Sun* that *Day* ſets at 4 *h.* 59 *m.* that is 59 *m.* after 4. and riſeth at 59 *m.* 8 *h.* that is 59 *m.* before 8. or almoſt 7 a Clock. And ſo you muſt account them always, remembring, That as the *Minutes* follow the firſt *Figure*, ſo they muſt be reckoned in Time after: as they ſtand before the laſt *Figure*, ſo they muſt be reckoned in Time before it.

And think it not prepoſterous that the time of the *Sun's Setting* is ſet down before the *Riſing*; for the *Sun's Setting* is of moſt uſe, and the other ſerves in a manner for the filling up of the *Column*.

	ho.	*min.*
If you double this time of Sun Setting	04	59
You have the Length of the Day	09	58
If you ſubſtract it from	12	00
You have the time of Riſing, *differing in ſhew from the* Kalendar	07	01
But all one in effect; and this doubled, ſhews the Length of the Night	14	02

IV. *To*

IV. *To find the Place of the* Sun.

THis is set down in the *Kalendar*, about every tenth *Day*, to every tenth *Degree*; so that reckoning a *Degree* for each *Day* between, you shall have the Place of the *Sun* exact enough for most ordinary Uses. Thus the 10th of *March* the *Sun* enters into *Aries*; therefore the 15th *Day*, or five *Days* after, the *Sun* is in five *Degrees* of *Aries*.

V. *To find the* Day *and* Hour *of the* Change *or* New Moon, *and thereby the* Full *and* Quarters.

FIrst you must find the *Moon's Epact* for the present *Year* you are in: This *Number* is found out in the *First Book*, *Page* 12. and also in the *Table* before at the beginning of the *Kalendar*. The *Change* also may be found out by the *Golden Number*; yet that would stand so scattering and without form, that it is much handsomer and readier to find out by this *Epact*, which runs for the most part in a Constant Order, only here and there skipping a *Day* or a *Number*, which is marked with this ✱.

Having found out the *Epact* for this present *Year*, turn to the *Month* you desire, and there find out the said *Number* of the *Epact* in the third *Column* of the *Months*, and mark what *Day* of the *Month* it stands against; for that is the *Day* of the *Change* or *New Moon*. Likewise if you have respect unto the *Dominical Letter*, which is by it, you shall see what *Day* of the *Week* it is.

Now here in this *Column* there are two Rows of *Figures*; The first shews the *Epact-Number*, and the next the *Time* of the *Day* reckoned by the *Hours* from *Noon*, which are plain to understand till you come to 12 *Hours* after *Noon*, which is *Midnight*; but then the *Numbers* above 12, you must reckon to the *Morning* of the next *Day*.

So that these *Hours* after *Noon*,

13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24,

are all one with these,

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,

the next *Day* in the *Morning*.

Thus in the *Year* 1666. the *Epact* being 4, and the *Dominical Letter* G, you shall find this *Epact-Number* 4 against the 21 of *July* being *Saturday*; and the *Figure* 0 standing by it, shews that the *New Moon* is just at *Noon*.

Again, You shall find the *Epact-Number* against the 16th of *November*, being *Friday*; and the *Figure* of 2 standing by it, shews that it is about 2 *Hours* after *Noon* the *Moon* changeth. Now this is the true time of the *New Moon*, according to the *Moon's mean Motion*; which though it may differ half a day from the true *Change*, yet it seldom differs so much, and is better for the following *Conclusion* than the true time.

Having first found out the time of the *New Moon*, you may from thence reckon the *Age* of the *Moon*, and find the *Quarters* and *Full Moon*.

Thus the *Moon's Age* is	Days	Hours	Min.
At the First Quarter	7	09	11
At the Full Moon	14	18	22
At the Last Quarter	22	03	33
An Whole Moon	29	12	44

Or else observe the *Dominical Letter* that is against the *Epact*, or *Day* of the *New Moon*; and where you find that *Letter* again, that is the *First Quarter*; for the *Full Moon* take two *Weeks* and one *Day*, which will fall upon the *Letter* next to it; for the *Last Quarter* take one *Week* more, which will fall upon the *Letter* of the *Full Moon*.

Thus

Thus if the *New Moon* fall upon A, the *Firſt Quarter* falls upon the next A, and the *Full Moon* on the next B a *week* after, and the *Laſt Quarter* on the next B. And thus you have this brief *Kalendar* or *Conſtant Almanack* for many *Years*; only for the more exactneſs in the *Hour* of the *Moon's Change* and *Age*, it is reſtrained to 19 *Years*: For though the *Change* of the *Moon* (for the moſt part) hapneth again upon the ſame *Days*, for ſeveral *Revolutions* of the *Prime* or *Golden Number* XIX; yet not upon the ſame *Hour* of the *Day*, but alters every *Revolution* 7 *Hours*, 27 *Minutes*, 30 *Seconds*, proceeding forward for the moſt part; but the *Leap-years* coming in with a *Day* more than ordinary, keeps this Motion ſo much backward, that in 300 *Years* it neither gains nor loſeth a *Day*, only differeth in the *Hour* of the *Day*; yet for the more exactneſs, it will be better to renew this every 19 *Years*. All theſe things this brief *Kalendar* ſhews plainly, with little or no trouble more than in an yearly *Almanack*. I ſhall now proceed to ſome other *Concluſions*. I have been very large already, in the *Firſt Book*, of Things concerning the Uſe of the *Moon* in other *Concluſions*; to which I refer you for any thing of the *Tides*, or the *Southing* of the *Moon*, or the *Riſing* or *Setting* of the *Moon*, or what elſe is neceſſary in *Navigation*.

I thought to have entred my *Figure* of the *Sea-Compaſs*, for the *Surveying* of *Land*, which was promiſed in the *Argument*; As likewiſe the *Gunner's Scale* and *Ganging Rod*: But I refer you to the ſeveral *Books* in the following *Treatiſe*, where the *Figure* and the Uſe of it, is together for your ſatisfaction.

The End of the Second Book.

THE Mariners Magazine; OR, STURMY'S Mathematical and Practical ARTS.

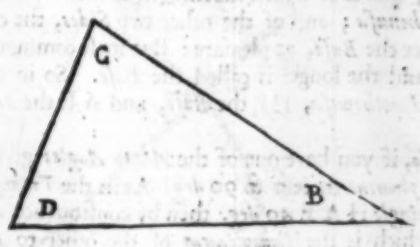
The Third Book.

CHAP. I.

Of the Nature and Quality of Triangles.

THis *Third Book* is as it were a *Key* to theſe that follow, the Subject whereof is *Trigonometry*; therefore I hold it convenient before I come to the following *Practice*, to ſay ſomething concerning *Plain Triangles* at leaſt, although that *Subject* be handled by divers more able *Mathematicians* already, whoſe Works are extant, (*viz.*) *Pitiſcus*, *Snellius*, the Lord *Napier*, Maſter *Gunter*, Maſter *Norwood*, Maſter *Gellibrand*: ſo that thoſe who deſire to make a farther ſcrutiny into *Trigonometry*, may peruſe the forementioned *Authors*.

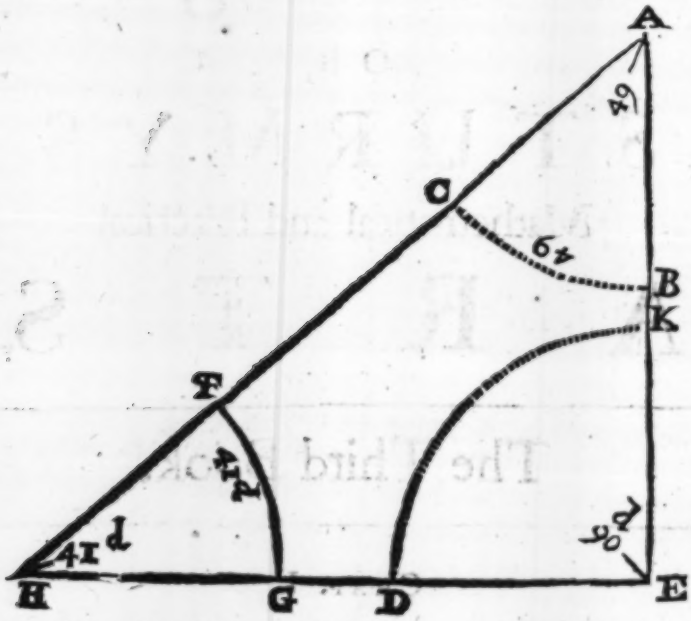
Before we come to ſhew how the Quantity of the *Sides* and *Angles* of any *Triangle* may be found by the *Tables* of *Artificial Sines* and *Logarithms*, and by the *Lines* of *Artificial Sines*, *Tangents*, and *Numbers*, take theſe following *Theorems*, as Neceſſaries thereunto.



I. A *Triangle* is a *Figure* conſiſting of three *Sides*, and three *Angles*, as in the *Figure* D B C.

II. Any two *Sides* of a *Triangle*, are called the *Sides* of the *Angle* comprehended by them; as the *Sides* C B and D B, are the *Sides* containing the *Angle* C B D.

III. The *Meaſure* of an *Angle* is the Quantity of an *Arch* of a *Circle*, deſcribed on the *Angular Point*, and cutting both the containing *Sides* of the ſame *Angle*; As in the *Triangle* following, the *Arch* C B is the Meaſure of the *Angle* at A, the *Arch* K D is the Meaſure of the *Angle* at E, and the *Arch* F G is the Meaſure of the *Angle* at H. Each of theſe *Arches* are deſcribed on the *Angular Points* A, H, E, and cut the containing *Sides*.



IV. A *Degree* is the 360 part of a *Circle*.

V. A *Semicircle* containeth 180 *Degrees*.

VI. A *Quadrant* containeth 90 *Degrees*.

VII. The *Complement* of an *Angle* leſs than a *Quadrant*, is ſo much as that *Angle* wanteth of 90 *Degrees*; as if the *Angle* A H E ſhould contain 41 *deg.* the *Complement* thereof would be 49 *deg.* For if you take 41 from 90, there will remain 49 *deg.*

VIII. The *Complement* of an *Angle* to a *Semicircle*, is the Remainder thereof to 180 *Degrees*.

IX. An *Angle* is either *Right*, *Acute*, or *Obtuſe*.

X. A *Right Angle* is that whoſe Meaſure is a *Quadrant*.

XI. An *Acute Angle* is leſs than a *Right Angle*.

XII. An *Obtuſe Angle* is greater than a *Quadrant*.

XIII. A *Triangle* is either *Right-Angled*, or *Obtuſe-Angled*.

XIV. A *Right-Angled Triangle* is that which hath one *Right Angle*; as the *Triangle* A H E is *Right-Angled* at E.

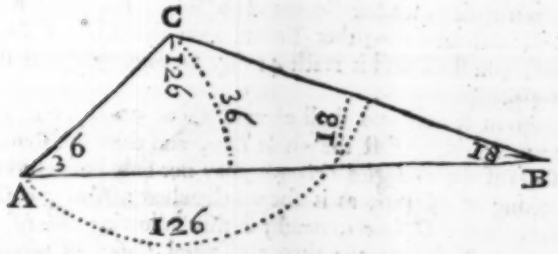
XV. In every *Right-Angled Triangle*, that *Side* which ſubtendeth or lieth oppoſite to the *Right Angle*, is called the *Hypothenuſa*; and of the other two *Sides*, the one is called the *Perpendicular*, and the other the *Baſe*, at pleaſure: But moſt commonly the ſhorteſt is called the *Perpendicular*, and the longer is called the *Baſe*. So in the former *Triangle*, the *Side* A H is the *Hypothenuſa*, H E the *Baſe*, and A E the *Perpendicular*.

XVI. In every *Right-Angled Triangle*, if you have one of the *Acute Angles* given, the other is alſo given, it being the *Complement* thereof to 90 *deg.* As in the *Triangle* A H E, ſuppoſe there were given the *Angle* H A E 49 *deg.* then by conſequence the *Angle* A H E muſt be 41 *Degrees*, which is the *Complement* of the other to 90 *Degrees*.

XVII. The three *Angles* of any *Right-Lined Triangle* whatſoever, are equal to

two

two *Right Angles*, or to 180 *Degrees*: So that if of any *Right-Lined Triangle*, you have any two of the *Angles* given, you have the third *Angle* alſo given, it being the *Complement* of the other to 180 *Degrees*.



So in this *Triangle* A B C, if there were given the *Angle* B A C 36 *Degrees*, and the *Angle* A C B 126 *Degrees*, I ſay by the conſequence, there is alſo given the third *Angle*. For if you add the two given *Angles* together, and ſubſtract it from 180 *Degrees*, there will remain A B C 18 *Degrees*: The two given *Angles* being taken from 180, the Remainder is the *Angle* required.

In all plain *Triangles* whatſoever, the *Sides* are in proportion one to the other, as the *Sines* of the *Angles* oppoſite to thoſe *Sides*. So in the *Triangle* A B C, the *Sine* of the *Angle* A C B is in ſuch proportion to the *Side* A B, as the *Sine* of the *Angle* C A B is to the *Side* B C. And ſo of any other.

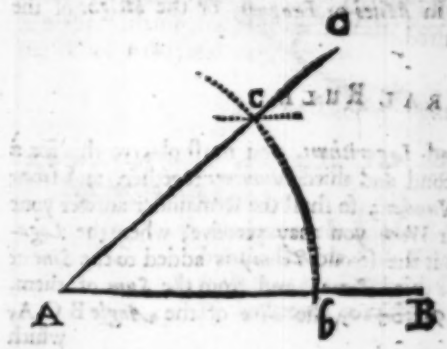
CHAP. II.

Containing the Doctrine *of the* Dimenſions *of* Right-Lined Triangles, *whether* Right-Angled *or* Oblique-Angled; *and the ſeveral* Caſes *therein reſolved, both by* Tables, *and alſo by the* Lines *of* Artificial Numbers, Sines, *and* Tangents.

I Come now to ſhew you how a *Plain Triangle* may be reſolved; that is, by having any three of the ſix Parts of a *Plain Triangle*, to find a fourth by the *Inſtruments* before-mentioned.

In all the *Caſes* following I have made uſe of but two *Triangles* for *Examples*; one *Right-Angled*, the other *Oblique-Angled*: But in either of them I have expreſſed all the Varieties that are neceſſary; ſo that any three Parts being given in any of them, a fourth may be found at pleaſure.

The *Sides* of any *Plain Triangle* may be meaſured by any *Meaſure* or *Scale* of *Equal Parts*; as an *Inch* divided into 10 *Parts*, or 20, 30 *Parts*; or likewiſe into *Inches, Feet, Yards, Poles, Miles*, or *Leagues*.



How to lay down an Angle by the Line of Chords.

Draw a *Line* at pleaſure, as A B; and from the *Point* A let it be required to protract an *Angle* of 41 *deg.* 24 *min.* Firſt extend the *Compaſſes* upon the *Line* of *Chords*, from the beginning thereof to 60 *deg.* always, and with this diſtance ſetting one Foot upon the *Point* A, with the other deſcribe the pricked *Arch* B C: Then with your *Compaſſes* take 41 *deg.* 24 *min.* (which is the Quantity of the inquired *Angle*) out of the *Line* of *Chords*, from the beginning thereof

thereof to 41 *deg.* 24 *min.* Keeping the *Compaſſes* at this diſtance, if you ſet one Foot thereof upon B, the other will reach upon the *Arch* to C. Laſtly, draw the *Line* A C. So the *Angle* C A B ſhall contain 41 *deg.* 24 *min.*

To find the Degrees *contained in an* Angle.

Suppoſe C A B were an *Angle* given, and that it were required to find the *Quantity* thereof. Open your *Compaſſes*, as before, to 60 *deg.* of your *Chord*; and placing one Foot in A, with the other deſcribe the *Arch* B C. Then take in your *Compaſſes* the *Diſtance* C B, and meaſuring that Extent upon the *Line* of *Chords*, from the beginning thereof, you ſhall find it reach 41 *deg.* 24 *min.* which is the *Quantity* of the inquired *Angle*.

If any *Angle* given or required ſhall contain above 90 *Degrees*, you muſt then pretract it at twice, by taking firſt the whole *Line*, and then the Remainder.

The ſeveral *Caſes* of *Right-Angled Triangles*, may not only be applied to *Navigation*, but alſo in the taking of *Heights*, as is ſhewn elſewhere: And the *Oblique-Angled Triangle*, for the taking of *Diſtances*, taught in this following *Treatiſe*.

In the reſolving of *Plain Triangles* there are ſeveral *Caſes*, of which I will only inſiſt on theſe, which have moſt relation to the Work in hand.

Of Right-Angled Plain Triangles.

Case I.

In a Right-Angled Plain Triangle, *The* Baſe *and the* Angle *at the* Baſe *being given, To find the* Perpendicular.

SUppoſe that the *Line* C A (in the following *Figure*) in the *Right-Angled Triangle*, were a *Tree*, *Tower*, or *Steeple*, and that you would know the *Height* thereof; you muſt obſerve with your *Inſtrument* the *Angle* C B A, and meaſure the *Diſtance* B A.

So have you in the *Right-Angled Triangle* A B C, the *Baſe* 405 *Foot* (*Miles* or *Leagues* the denomination might have been as well) and the *Angle* at the *Baſe* 32 *deg.* and it is required to find the *Perpendicular* A C.

Now becauſe the *Angle* C B A is given, the *Angle* B C A is alſo given, it being the *Complement* of the other to 90 *deg.* and therefore the *Angle* B C A is 58 *Degrees*: Then to find the *Perpendicular* C A, the *Proportion* is,

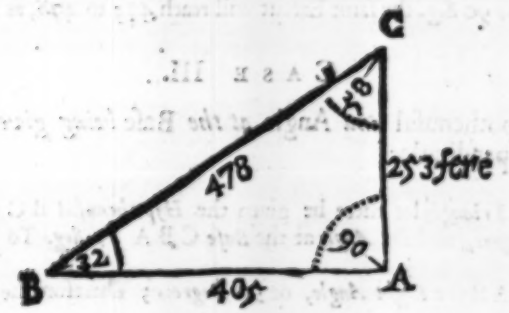
As the Sine *of the* Angle B C A 58 deg. (*which is*)	9928420
Is to the Logarithm *of the* Side B A 405 Foot	2607455
So is the Sine *of the* Angle C B A 32 deg. (*which is*)	9724210
The Sum *of the Second and Third added*	12331665
The firſt Number *ſubſtracted from the* Sum	9928420
To the Logarithm *of the* Side C A	2403245

The neareſt *Abſolute Number* anſwering to this *Logarithm* 2403245, is 253 *fere*; and that is the *Length* of the *Side* C A in *Miles* or *Leagues*, or the *Height* of the *Tree*, *Tower*, or *Steeple*, which was required.

A General Rule.

IN all *Proportions* wrought by *Sines* and *Logarithms*, you muſt obſerve this for a *General Rule*, (*viz.*) To add the ſecond and third *Numbers* together, and from the *Sum* of them to ſubſtract the firſt *Number*; ſo ſhall the Remainder anſwer your *Queſtion* demanded. As by the former *Work* you may perceive, where the *Logarithm* of the *Side* B A 2607455 (which is the ſecond *Term*) is added to the *Sine* of the *Angle* C B A 9724210 (which is the third *Term*) and from the *Sum* of them, namely from 12331665, is ſubſtracted 9928420, the *Sine* of the *Angle* B C A, which

which is the firſt *Number*, and there remaineth 2,403245, which is the *Logarithm* of 253 almoſt, and that is the *Length* of the *Side* required.



To reſolve the ſame Work *by the* Line *of* Sines *and* Numbers.

YOu may work theſe *Proportions* more eaſily by help of the *Line* of *Sines*, *Tangents*, and *Numbers*, on your *Scale*, the *Proportion* being as before. *Place here the* Line *of* Numbers, Sines, *and* Tangents.

Therefore if you ſet one Foot of your *Compaſſes* at 58 *deg.* in the *Line* of *Sines*, and extend the other *Foot* to 405 in the *Line* of *Numbers*, the ſame will reach from the *Sine* of 32 *deg.* to 253 in the *Line* of *Numbers*, which is the *Length* of the *Side* A C, which was required.

Or otherwiſe, Extend the *Compaſſes* from the *Sine* of 32 *deg.* to the *Sine* of 58 *deg.* in the *Line* of *Sines*; the ſame Extent will reach from 405 in the *Line* of *Numbers*, to 253, as before, the Work is much abbreviated, there being no need of *Pen*, *Ink*, nor *Paper*, or *Tables*; but only of your *Compaſſes*.

CASE II.

The Baſe *and the* Angle *at the* Baſe *being given*, *To find the* Hypothenuſa.

IN the ſame *Triangle* A B C, Let there be given (as before) the *Baſe* A B 405 *Foot*, *Miles*, *Leagues*, or *Perches*, and the *Angle* A B C 32 *deg.* and let it be required to find the *Hypothenuſa* B C. Now becauſe the *Angle* C B A is given, the other *Angle* B C A is alſo given; and the Proportion is,

As the Sine *of the* Angle B C A 58 deg.	9, 928420
To the Logarithm *of the* Side 405 Foot	2, 607455
So is the Sine *of the* Angle C A B 90 deg.	10, 000000
The Sum *of the ſecond and third* Number	12, 667455 *added*
To the Logarithm *of the* Side B C, *which is*	2, 679035

The *Abſolute Number* anſwering to this *Logarithm* is 478; and ſo many *Feet*, *Miles*, *Leagues*, *Perches* is the *Hypothenuſa*, according to the denomination of the *Queſtion*; that is, whether it be *Feet*, *Perches*, *Miles*, or *Leagues*. By either of theſe the Work is the ſame way.

By the Line *of* Numbers *and* Sines.

AS was ſaid before, the Work is altogether the ſame with the *Tables*; For the Proportion being,

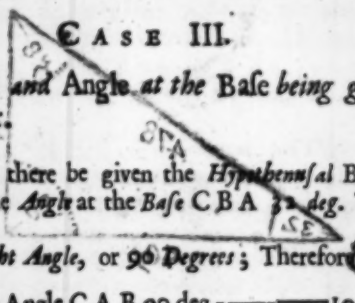
As the Sine *of the* Angle B C A 58 degrees
Is to the Length *of the* Side B A 405 Foot:
So is the Sine *of the* Angle C A B 90 Degrees,
To the Length *of the* Side C B 478.

Extend

Extend the *Compaſſes* from the *Sine* of 58 *deg.* to 405 in the *Line* of *Numbers*; the ſame Extent will reach from the *Sine* of 90 *deg.* to 478 in the *Line* of *Numbers*, and that is the *Length* of the *Side* B C. Or you may extend the *Compaſſes* from the *Sine* of 58 *deg.* to 90 *deg.* the ſame Extent will reach 405 to 478, as before.

Case III.

The Hypothenuſal *and* Angle *at the* Baſe *being given, To find the* Perpendicular.



IN the ſame *Triangle* let there be given the *Hypothenuſal* B C 478 *Feet, Poles, Miles, Leagues,* and the *Angle* at the *Baſe* C B A 32 *deg.* To find the *Perpendicular* C A.

The *Angle* C A B is a *Right Angle*, or 90 *Degrees*; Therefore the Proportion is,

As the Sine *of the* Angle C A B 90 deg	10, 000000
Is to the Logarithm *of the* Side B C 478	2, 679428
So is the Sine *of the* Angle C B A 32 deg.	9, 724210
To the Logarithm *of the* Side A C 253	12, 403638

The *Number* anſwering to this *Logarithm* is 253 *fere*; and that is the *Length* of the *Side* C A in *Feet, Poles, Miles,* or *Leagues.*

Here the *Work* is ſomething abbreviated; for the *Angle* C A B being a *Right Angle*, and being the firſt *Term*, when the ſecond and third *Terms* are added together, the firſt is eaſily ſubſtracted from it, by cancelling the *Figure* next your left hand, as you ſee in the *Example*; and ſo the reſt of that *Number* is the *Logarithm* of the *Number* ſought.

By the Line *of* Sines *and* Numbers.

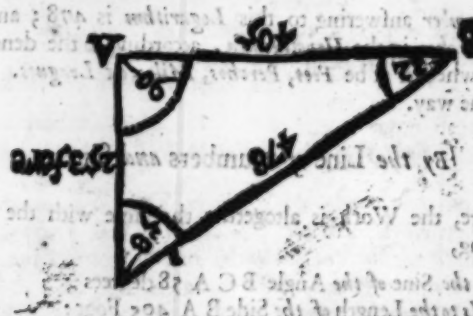
EXtend the *Compaſſes* from the *Sine* of 90 *Degrees*, to 478; the ſame Extent will reach from the *Sine* of 32 *Degrees*, to 253.

Or, Extend the *Compaſſes* from the *Sine* of 90 *Degrees*, to the *Sine* of 32 *Degrees*; the ſame Extent will reach from 478, to 253; and that is the *Side* C A.

Case IV.

The Hypothenuſal *and* Angle *at the* Baſe *being given, To find the* Baſe.

LEt there be given in the *Triangle* the *Hypothenuſal* B C, and the *Angle* at the *Baſe* C B A; and by conſequence the *Angle* B C A the *Complement* of the other to 90 *degrees*: Then to find B A, the Proportion is,



As the Sine *of* 90 deg. C A B——————————10, 000000
To the Hypothenuſal C B 478——————————2, 679428
So is the Sine *of the* Angle A C B 58 ——————9, 928420
To the Logarithm *of the* Baſe A B——————12, 607848

The neareſt *Number* anſwering to 2, 607848, is the *Logarithm* of 405: And ſo many *Foot* or *Poles*, or if the Queſtion be *Miles* or *Leagues*, is the *Baſe* or *Parallel* of *Longitude* A B.

Now you ſee the former *Figure* is turned, and therefore very fitly may have other *Denominations* (or *Names*) ſo that in the *Art* of *Navigation*, it will not be unfit to call one of theſe *Sides* the *Parallel-Side*, as A B, or *Side* of *Longitude*, or *Meridian Diſtance*; the other the *Perpendicular-Side*, or the *Side* of *Latitude*, as C A; and the *Hypothenuſal*, the *Side* of *Diſtance* C B, and the *Arches* to lay down from the *Chords*, as before-directed.

By the Line *of* Sines *and* Numbers.

THe *Angle* given, as before, Extend the *Compaſſes* from the *Sine* of 90 *deg.* unto 478. the ſame Extent will reach from the *Sine* of 58 *deg.* to 405 in the *Line* of *Numbers*.

Or, Extend the *Compaſſes* from the *Sine* of 90 *deg.* to the *Sine* of 58 *deg.* the ſame Extent will reach from 478 to 405, which is the *Length* of the *Baſe* turned up, or *Parallel-Line* of *Longitude*, as before ſaid, A B.

CASE V.

Let the Perpendicular *be the* Difference *of* Latitude 253 Leagues, *and the* Angle *at* C, S. W. b. W. 1 deg. 45 min. Weſterly, *or* 58 deg. *Let it be given to find the* Hypothenuſal *or* Diſtance *upon the* Rhomb.

IF the *Perpendicular* or *Difference* of *Latitude* 253 *Leagues* A C be given, and the *Angle* at A C B, *S. W. b. W.* 1 *deg.* 45 *Weſterly*, or 58 *deg.* Then by conſequence the *Angle* A B C, or *Complement* of the *Rhomb* is alſo given; taking the firſt out of 90 *deg.* then the *Hypothenuſal* may be found thus.

As the Complement Sine *of the* Rhomb 32 deg. *at* B——— 9, 724210
Is to the Logarithm *of the* Difference *of* Latitude 253——12, 403121
So is the Sine *of the* Angle *or* Radius 90 deg.——————10, 000000
To the Logarithm *of the* Hypothenuſal, *or* Diſtance *upon the* Rhomb *or* Courſe *ſailed* 478——————2, 678911

Here becauſe the *Angle* C A B is a *Right Angle*, or 90 *Degrees* the *Radius*, and comes in the third place, I therefore only put an *Unity* before the ſecond *Term*, and ſo ſubſtract the firſt *Term*, and the Remainder is 2, 678911; the *Abſolute Number* anſwering thereunto is 478, the *Side* required.

By the Line *of* Numbers.

EXtend the *Compaſſes* from the *Sine* of 32 *deg.* to 253 *deg.* the ſame *Diſtance* will reach from the *Sine* of 90 *deg.* to 478, the *Side* required.

Or, The *Diſtance* between the *Sine* of 32 *deg.* and 90 *deg.* will be equal to the *Diſtance* between 253 and 478, and giveth the *Side* required.

CASE VI.

The Hypothenuſal *or* Diſtance *Sailed, and the* Perpendicular *or* Difference *of* Latitude *given, To find the* Rhomb *or* Angle A B C.

IN the foregoing *Triangle*, there is given the *Hypothenuſal* or *Diſtance* ſailed, C B 478 *Leagues*, and the *Perpendicular* or 253 *Leagues* difference of *Latitude*, and it is required to find the *Angle* A B C, and by it the *Rhomb*.

As the Logarithm *of the* Hypothenuſal C B 478 Leagues——	2, 679428
Is to the Right Angle *or* Radius 90 deg. C A B——	10, 000000
So is the Logarithm *of the* Perpendicular 253 C A——	2, 403121
To the Complement Sine *of the* Rhomb, *or* Sine *of the* Angle A B C 32 deg.——	9, 723693

The neareſt *Number* anſwering to 9, 723693, is the *Sine* of 32 *deg.* which deducted from 90 *deg.* there remains the *Angle* of the *Rhomb* 58 *deg.* or *S. W. b. W.* 1 *deg.* 45 *VVeſterly.*

By the Line *of* Numbers.

EXtend the *Compaſſes* from 478, to the *Sine* of 90; the ſame *Diſtance* will reach from 253, to 32 *deg.*

Or, Extend the *Compaſſes* from 478, to 253; the ſame Extent will reach from the *Sine* of 90, to the *Sine* of 32 *deg.* which is the inquired *Angle* A B C, and the *Complement* of the *Rhomb.*

CASE VII.

The Hypothenuſal, *and the* Parallel *of* Longitude, *and the* Radius *given, To find the* Rhomb *or* Courſe *Sailed.*

IN the foregoing *Triangle* there is given the *Hypothenuſal* or *Diſtance* Sailed, C B 478 *Leagues*, and the *Right Angle* C A B 90 *deg.* the *Radius*, and the *Parallel* of *Longitude* or *Baſe* 405 *Leagues*, to find the *Courſe* or *Rhomb* ſailed, or the *Angle* A C B.

As the Hypothenuſal *or* Diſtance *ſailed* 478 C B——	2, 679428
To the Right Angle C A B Radius *or* Sine *of* 90 *deg.*——	10, 000000
So is the Parallel *of* Longitude, *or* Baſe A B 405 Leagues——	12, 607455
To the Sine *of the* Angle *of the* Rhomb *or* Courſe *ſailed* 58 or *S. W. b. W.* 1 *deg.* 45 *Weſterly*——	9, 928027

By the Lines *of* Sines *and* Numbers.

EXtend the *Compaſſes* from 478 in the *Line* of *Numbers*, to the *Sine* of 90 *deg.* the ſame Extent will reach from 405, to the *Sine* of 32 *deg.*

Or, Extend the *Compaſſes* from 478 to 405; the ſame Extent will reach from the *Sine* of 90, to the *Sine* of 32 *deg.* A C B, the *Angle* of the *Rhomb* or *Courſe* ſailed, which was required.

Of Oblique-Angled Plain Triangles.

CASE VIII.

Having two Angles, *and a* Side *oppoſite to one of them, To find the* Side *oppoſite to the other.*

IN the *Triangle* QRS, is given the *Angle* QSR 25 *deg.* 30 *min.* and the *Angle* QRS 45 *deg.* 20 *min.* and the *Side* QS 305 *Feet*; And it is required to find the *Side* QR.

Here note, That in *Oblique-Angled Plain Triangles*, as well as in *Right-Angled*, the *Sides* are in proportion one to the other, as the *Sines* of the *Angles* oppoſite to thoſe *Sides*: Therefore,

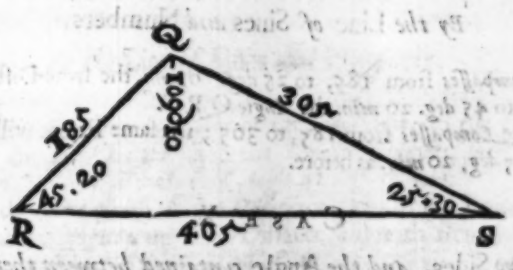
As the Sine *of the* Angle QRS 45 deg. 20 min.	9, 851997
Is to the Logarithm *of the* Side QS 305	2, 484299
So is the Sine *of the* Angle QSR 25 deg. 30 min.	9, 633984
The Sum *of the ſecond and third* Terms	12, 118283
The firſt Term *ſubſtracted*	9, 851997
To the Logarithm *of the* Side QR	2, 266286

The neareſt *Abſolute Number* anſwering to this *Logarithm* is 185; and ſo many *Feet* is the *Side* QR.

By the Line *of* Sines *and* Numbers.

THE *Line* of *Sines* and *Numbers* will reſolve the *Triangle* by the ſame manner of Work, as in the other before. For if you extend the *Compaſſes* from the *Sine* of 45 *deg.* 20 *min.* to 305 *Foot*, the ſame Diſtance will reach from 25 *deg.* 30 *min.* to 185 *Foot*, and ſo much is the *Side* QR.

Or, Extend the *Compaſſes* from the *Sine* af 45 *deg.* 20 *min.* to 25 *deg.* 30 *min.* the ſame Diſtance will reach from 305 to 185, the *Length* of the *Side* inquired.



In like manner if the *Angle* RQS, 109 *deg.* 10 *min.* and the *Angle* QRS 45 *deg.* 20 *min.* and the *Side* QS 305 *Foot*, had been given, and the *Side* RS required, the manner of Work had been the ſame: For,

As the Sine *of the* Angle QRS 45 deg. 20 min.	9, 851997
Is to the Logarithm *of the* Side QS 305	2, 484299
So is the Sine *of* RQS 109 deg. 10 min. (*or* 70 deg. 50 min.)	9, 975233
The Sum *of the ſecond and third* Terms	12, 459532
The firſt Term *ſubſtracted*	9, 851997
To the Logarithm *of the* Side RS 405	2, 607535

The *Abſolute Number* anſwering to this *Logarithm* is 406, and ſo much is the *Side* R S.

In this Caſe, becauſe the *Angle* R Q S is more than 90 *Degrees*, you muſt therefore take the *Complement* thereof to 180 *deg.* ſo 109 *deg.* 10 *min.* being taken from 180 *deg.* there remains 70 *deg.* 50 *min.* whoſe *Sine* is the ſame with 109 *deg.* 10 *min.* And ſo you muſt work with all *Angles* above 90 *Degrees*; and ſo will the *Complement* to 180, as before-directed, effect the ſame thing.

By the Line *of* Numbers *and* Sines.

EXtend the *Compaſſes* from the *Sine* of 45 *deg.* 20 *min.* to 305 *Feet*, the ſame Diſtance will reach from 70 *deg.* 50 *min.* to 405.

Or, The *Compaſſes* extended from the *Sine* of 45 *deg.* 20 *min.* to 70 *deg.* 50 *min.* the ſame Extent will reach from 305, to 406 in the *Line* of *Numbers*, which is the *Side* R S required.

CASE IX.

Two Sides, *and an* Angle *oppoſite to one of them being given, To find the* Angle *oppoſite to the other.*

IN the ſame *Triangle*, let there be given the *Side* Q S 305, and Q R 185 *Feet*, together with the *Angle* Q S R 25 *deg.* 30 *min.* and let it be required to find the *Angle* Q R S. The Proportion is,

As the Logarithm *of the* Side Q R 185	2, 267172
Is to the Side *of the* Angle Q S R 25 deg. 30 min.	9, 633984
So is the Logarithm *of the* Side Q S 305	2, 484299
The Sum *of the ſecond and third* Numbers	12, 118283
The firſt Number *ſubſtracted from the* Sum	2, 267172
To the Sine *of the* Angle Q R S 45 deg. 20 min.	9, 851111

The neareſt *Degree* anſwering to this *Sine* is 45 *deg.* 20 *min.* which is the *Angle* required Q R S.

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from 185, to 25 *deg.* 30 *min.* the ſame Diſtance will reach from 305, to 45 *deg.* 20 *min.* the *Angle* Q R S.

Or, Extend the *Compaſſes* from 185, to 305; the ſame Extent will reach from 25 *deg.* 39 *min.* to 45 *deg.* 20 *min.* as before.

CASE X.

Having two Sides, *and the* Angle *contained between them given, To find either of the other* Angles.

FOr the performance of this *Problem*, Suppoſe there were given the *Side* R S 406, and the *Side* R Q 185, and the *Angle* comprehended by them, namely the *Angle* at R, 45 *deg.* 20 *min.* and it were required to find either of the other *Angles*.

Firſt, Take the *Sum* and *Difference* of the two *Sides* given; their *Sum* is 591, and their *Difference* is 221. Then knowing, that the three *Angles* of all *Right-lined Triangles*, are equal to two *Right Angles*, or 180 *Degrees* (by the 17th *Theor.* of *Chap.* 3.) Therefore the *Angle* S Q R being 45 *deg.* 20 *min.* if you ſubſtract this *Angle* from 180 *deg.* the Remainder will be 134 *deg.* 40 *min.* which is the *Sum* of the two unknown *Angles* at Q and S; the half thereof is 67 *deg.* 20 *min.*

The

The Side R S—406 *Paces.*
The Side R Q—185 *Paces.*

The Sum——591 *of the* Sides *given*, R S *and* R Q.
The Difference—221 *of the* Sides.

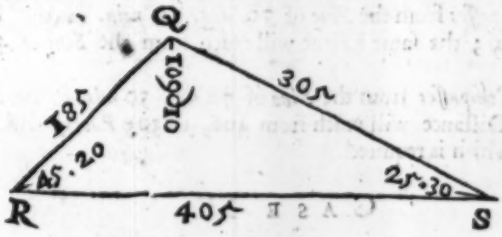
	deg.	*mi.*
Two Right Angles—	180	00
The Angle *at* R——	45	20
The Sum *of the two opposite* Angles—	134	40
The Half-Sum——	67	20

The *Sum* and *Difference* of the *Sides* being thus found, and alſo the *Half-Sum* of the two unknown *Angles*, The Proportion by which you muſt find the *Angles* ſeverally is,

As the Logarithm *of the* Sum *of the* Sides 591—— 2771587
Is to the Logarithm *of the* Difference *of the* Sides 221—— 344392
So is the Tangent *of the* Half-Sum *of the two unknown* Angles 67 deg. 20 min.—— 10379213
The Sum *of the ſecond and third* Number—— 12723605
The firſt Number *ſubſtracted from the* Sum—— 2771587
The Tangent *of* 41 deg. 50 min. (*is this*)—— 9952018

Which added to the Half-Sum, *makes*—109 *deg.* 10 *min.* Greater Angle.
The greater of the Angles *required*, *Subſtract* 41 deg. 50 min. *from the* Half-Sum, *leaves the leſſer* Angle *at* S 25 *deg.* 30 *min.* Leſſer Angle.

½ *Sum*	67	20
Tang.	41	50
	109	10
Leſſer Angle	25	30



By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from the *Sum* of the *Sides* 591, to the *Difference* of the *Sides* 221; the ſame Extent upon the *Line* of *Tangents*, will reach from the *Half-Sum*, to the *Tangent* of the found *Angle* 41 *deg.* 50 *min.*

Or elſe extend the *Compaſſes* from the *Difference* 221, to the *Tangent* of the *Half-Sum* of the unknown *Angles*; the ſame Diſtance will reach from the *Half-Sum* 67 *deg.* 20 *m.* in the ſame *Line*, to the *Tangent* of 41 *deg.* 50 *min.* which added to, or ſubſtracted from the *Half-Sum*, as before is ſhewn, will give the Quantity of either of the two unknown *Angles.*

CASE

Case XI.

Two Sides *and their* Containing Angle *given, To find the third* Side.

THere is given R S 406 *Paces*, and R Q 185 *Paces*, and the *Angle* at R 45 *deg.* 20 *min.* which is by the 10 *Case*,

As the Sum *of the* Sides *given* R S + R Q 594 p.	2771587
Is in proportion to their Difference R S + R Q 221	2344392
So is the Tangent *of the* Half Sum *of the* 67 deg. 20 min.	10179213
Two oppoſite Angles Q *and* S *unknown*, 2, 3 Numb.	12723605
To the Tangent *of the* Angle 41 *d.* 50 *m.*	9952018
Which added to the Half Sum 67 20	
Leaves the greater Angle *at* Q *required* 109 10	
Whoſe Complement *to* 180 deg. *is* 70 50	

Then ſay,

As the Sine *of the* Angle *found* 109, *or* 70 deg. 50 min.	9,975233
Is in proportion to his oppoſite Side R S 406 Paces	2,608526
So the Sine *of the* Angle *given at* R 45 deg. 20 min.	9,851997
To his oppoſite Side *required* Q S 305 Paces	12,464523
The Logarithm *of the* Side *required*	2,485290

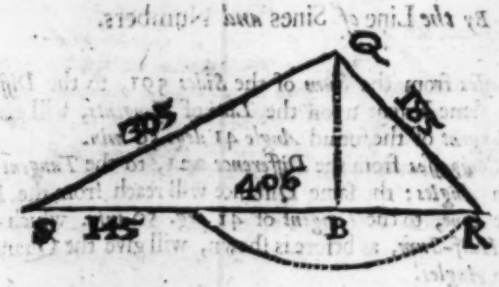
By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from the *Sine* of 70 *deg.* 50 *min.* to the *Logarithm-Side* R S 406 *Paces*; the ſame Extent will reach from the *Sine* of 45 *deg.* 20 *min.* to the *Side* 305.

Or, Extend the *Compaſſes* from the *Sine* of 70 *deg.* 50 *min.* to the *Sine* of 45 *deg.* 20 *min.* the ſame Diſtance will reach from 406, to 305 *Paces*, which is the *Length* of the *Side* Q S, which is required.

Case XII.

Three Sides *of an* Oblique Triangle *being given, To find the* Angles.



IN this *Triangle* S Q R, Let the three *Sides* known,

The Side S R	406
The Side S Q	305
The Side Q R	185

And it is required to find the three *Angles*.

To perform this, you muſt firſt let fall a *Perpendicular* from the *Point* Q, upon the *Side* S R, which you may do by ſetting one Foot of your *Compaſſes* in the *Point* Q, and open the other to the *Point* R, draw the *Arch* R E, and divide the *Space* E R into two equal parts; and ſo the *Perpendicular* will fall upon the *Point* B.

To

To perform this more exactly by *Numbers*,

As the greater Side *or* Baſe S R, 406	2,608526
To the Sum *of the two leſſer* Sides 490	2,690196
So is the Difference *of theſe two* Sides 120	2,079181
To the Part S E (*cut off by the* Arch R B E) 145	4,769377
	2,608526
	2,161851

This ſubſtracted from the whole *Line* 406, leaves for the part within the *Arch* 261; the half thereof is 130½, which is the Place B where the *Perpendicular* will fall, reckoned from the *Angle* R; and by this *Perpendicular* you have divided the *Triangle* into two *Right Angles*, whoſe *Sides* are known: For R B being 103½, ſubſtracted from the whole *Line* S R 406, leaves for the remaining Part 275½. Now having thoſe two *Sides* of theſe two *Right-Angled Triangles*, and the two firſt given *Sides*, 305 and 185, being the two *Hypothenuſals* thereof, you may by the oppoſition of *Sides* to their *Angles*, as in the *6 Caſe*; or by the *Sides* and *Hypothenuſal*, as in the *7 Caſe*, find the *Angles*.

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from 406, to 490; the ſame Diſtance will reach from 120, to 145 S E *Leagues*, the *Side* required.

Theſe are the moſt needful *Caſes* in the *Reſolution* of *Plain Triangles*, which might have been ſet forth with much Variety and Inlargement; but I rather ſtrive to ſhew the beſt and plaineſt way. The *Practitioner* being perfect in what hath been ſaid before, we will proceed to our intended *Diſcourſe* of *NAVIGATION*.

The End of the Third Book.

THE AUTHOR TO HIS Fourth Book.

MY *New-rigg'd* Ship, *Strike now thy* Sails,
Let ſlip thine Anchor, *the* Wind *fails*;
And Sea-men *oft in* Calms *do fear*
That foul and boiſt'rous Weather's *near.*
If a robuſtious Storm *ſhould riſe,*
And bluſter from cenſorious Eyes;
Although the ſwelling Waves *be rough,*
And proud, thy Harbour's *ſafe enough.*
Reſt, reſt a while, till Ebbing Tides
Shall make thee ſtanch, and breme thy Sides:
When VVinds *ſhall ſerve, hoiſe up thy* Sail,
And fly before a Proſp'rous Gale;
That all the Coaſters *may reſort,*
And bid thee Welcome to thy PORT.

THE Compleat Sea-Artiſt; OR THE ART OF NAVIGATION.

The Fourth Book.

CHAP. I.

Of Sailing by the Plain Chard, *and the Uncertainties thereof; And of* Navigation.

THE *Art* of *Navigation*, is a Knowledge by certain *Rules* for to Steer a *Ship* through the *Sea*, from the one Place to the other; and may not improperly be divided into two parts, namely, the *Common*, and alſo the *Great Navigation*.

The *Common Navigation* requireth the Uſe of no *Inſtruments* but the *Compaſs* and *Sounding-Lead*, as chiefly conſiſting in *Practice* and *Experience*, in Knowledge of *Lands* and *Points*, how they lie in Diſtance and Courſe one from the other, and how they are known at *Sea*, in knowledge of *Depths* and *Shoulds* and varieties of *Grounds*, the *Courſe* and *Setting* of *Tides*, upon what *Point* of the *Compaſs* the *Moon* maketh *High-water* in each ſeveral place, and the like; which muſt be reckoned partly by the Information of skilful *Pilots*, but far better by a Man's own Practice and Experience.

The *Great Navigation* uſeth, beſides the foreſaid *Common Practice*, divers other *Artificial Inſtruments* and *Rules*, which they muſt take out of *Aſtronomy* and *Coſmography*. It is therefore needful, that every *Pilot* and *Officer*, that takes charge of any *Ship* or *Veſſel* in the Practice of the *Great Navigation*, be firſt and chiefly well inſtructed in the principal *Points* of the foreſaid *Arts*; that is, that he know the Order and underſtand the Diviſion of the *Sphere* of the *World*, and the Motions of the *Heavens*, eſpecially the Eighth, Fourth, and Firſt; Together with the contriving or Making and Uſe of *Inſtruments*, as I have ſhewn briefly in the *Second Book*. Know this, Without this *Knowledge* it is impoſſible to perform great *Voyages* (not before attempted) over the *Sea*. In regard ſuch *Knowledge* may be attained to, by good *Inſtruction*, we have ſet forth the ſame in this *Treatiſe*, for the benefit of all ſuch young

Sea-faring Men, as are desirous to be *Sea-Artists* or *Navigators*, so clearly and plainly as the brevity of the same could suffer to be done.

The Defects and Imperfections of this *Art* are many; partly in the *Skill* or *Theorick*, partly in the *Practick*.

After a long *Voyage*, the *Ship* supposed to be near the *Shore*, the *Commander* or *Master* requires from their *Mates* an Account of their Judgement how the *Land* or *Cape* bears from them, the Course and Distance of it when they see it: He that comes nearest the *Shore*, is supposed to have kept the best *Reckoning*. I have known some that have not been scarce able to number and make five *Figures*, have gone neerest the *Shore* than the best *Artist* in the *Ship*; but they have been wonderfully mistaken, to my knowledge, in other *Voyages*. I went a *Voyage* to *Barbadoes* in the *Rainbow*, and took our *Reckoning* from *Lundy*, in the Mouth of *Severn*; and in the *Ship* were 12 *Practitioners* and Keepers of *Account*; eleven of them kept it by the *Plain Chart*, and my self made use of *Mercator* and Mr. *Wright*'s *Projection*. When we came in the *Latitude* (which was 400 *Leagues* from the *Shore*) every Man was ready to give his best Judgement of his Distance off the *Shore*: But they all fell wonderfully short of the truth; for he that should have had the best *Reckoning*, was 300 *Leagues* short, and most of all the rest was 268 and 250 *Leagues*; and he that was accounted an excellent *Artist* aboard the *Ship*, was 240. But by the *Reckoning* kept by *Mercator*'s *Chart*, which wanted but three *Leagues* short of the *Island*. In the same *Ship*, going from thence to *Virginia*, they also fell short, by the same way of *Account* by the *Plain Chart*, 90 *Leagues* the neerest; and those that were advised to keep it by *Mercator*, found it come but 4 or 5 *Leagues* short of the *Cape* of *Virginia*: But coming from thence home, they got their Credit mended; they came all within 30, 20, and 10 *Leagues* of the *Shore*.

So I say, If the Course and Distance had been first agreed upon from the Place they were bound to, to be just the same, unto the *Cape* or *Land* they first descried; If men differ then, there is something in that, in respect of the uncertainty of the *Longitude*: A bad *Reckoning* may prove better than a good.

But we find that there is near 180 *Leagues* difference Error, between the *Meridian* of *Barbadoes* and *Lundy*, and much more in the Distance; and in some *Charts* about 620 *Leagues* Errour, in the Distance between *Cape Fortuna*, the *South Cape* of *Anian Fretum*, to *Cape Hondo* by the River *Depiscadores*; and these Errors may be ascribed partly to the uncertainty of the *Longitude*, and partly unto the *Plain Chart*, and Sailing by it, which makes some Places nearer than they are, and other Places far more distant than they are, and scituated much out of their true *Course* or *Rhomb*.

Secondly, Men many times commit great Errors in bad Steerage, and careless looking to the *Compass*; for I have known many *Seamen* when their trike or turn have been out, and the *Log* hove, they have told the *Master* or his *Mate*, they have Steered ½ a *Point* a Weather the *Course*; besides, the *Points* of the *Needle* or *Wyres* being touched by the *Load-stone*, are subject to be drawn aside by the *Guns* in the *Steerage*, or any *Iron* neer it, and liable to *Variation*, and doth not shew the true *North* and *South*, which ought continually to be observed by a good *Meridian*, or as some call it an *Azimuth-Compass*, which is the proper Name. Such a one you have described, by which I Survey *Land* with, as is shewn in the following *Treatise*; so the Variation ought to be carefully allowed.

I found 11 degr. in a Field at S. George's and Bristol being four miles distant; and I made five Observations, as in p. 330. and differed ½ of a degr. only.

Besides, on *Land* there is great difference in the same *Country* and *Places*, as *Dialists* well know, by taking often the *Declination* of several *Walls*; as also Mr. *Gunter*'s *Observations* at *Limehouse*, for the finding of the Variation, found it ½ a *Degree* more, and other Places of the same Ground less; and *Mœtius* saith, he hath found a *Degree* or two difference. This difference at *Land* must needs shew the uncertainty we have at *Sea*. Besides, many times the *Ship* is carried away by unknown *Currents*, which when they be discovered by their *Ripplings*, as also some by reason of *Trade-Winds*, we set them in our *Journal*; as also if we meet with any *Soundings*, as there is in divers Places 100 *Leagues* off the *Land* or *Islands*, to my knowledge, I would advise all *Learners* to be careful to put down all such remarkable things as neer as he can, their *Latitude* and *Longitude*. So I believe did *Mœtius*, to remember the *Current* that set between *Brasilia* and *Angola*, in the opposite *Coasts* of *Africa*, where he instanceth,

ſtanceth, That an able *Maſter* bound to St. *Helen's*, in 16 *Degrees* of *South-Latitude*, in the mid-way betwixt both *Coaſts*, and being in the *Parallel* of *Latitude* thereof, ſteered *Eaſt*, was notwithſtanding carried by the unknown *Motion* of an unknown *Current* 800 *Miles Weſtward*, and yet ſtemmed the *Current* with a fair *Wind*, and at laſt made the *Coaſts* of *Braſilia*.

From the 10 of *April* to the 15 of *July*, the *Current* ſets near *North-Weſt*. From the 15 of *July* to the 12 of *October*, there is no *Current* perceivable. From the 12 of *October* to the 13 of *January*, it ſets *South-Weſt*; And from the 13 of *January* to the 12 of *April*, it ſeems to have no *Motion* perceivable. Again,

Currents as a means of great miſtake in keeping of a *Reckoning*; for Captain *Luke Fox* in his *North-Weſt* Diſcoveries, and the reſt, complained fearfully of the faſt *Lands* of *Ice* upon thoſe *Coaſts*, that ſo alters the *Currents*, that in ſome Places they cannot make good their *Courſe* they ſteer upon, by three *Points*; eſpecially in *Davis* his *Streights*, where ſteering *Eaſt-by-South*, they ſcarce could make good *South-Eaſt-by-South*, which is four *Points* of the *Compaſs*, and the Error at leaſt 70 *Leagues*.

I have alſo perceived a good *Current* to ſet to the *Eaſtward*, *E. S. E.* about the *Weſtern Iſlands*, and the *Madera's*, in ſeveral *Voyages* I have made to the *Weſt-Indies*; but more eſpecially I have obſerved it in my laſt *Voyage* to *Barbadoes*. I went out of *England* in Company with Captain *Jeremy Blackman*, in the *Eagle* bound to the *Eaſt-Indies*, and a *Dutch Ship* in his Company, and one of *Plymouth* for the *Iſle* of *May*: So we kept company together as far as the *Madera's*, but intended never to ſee it that *Voyage*; for we reckoned our ſelves 25 *Leagues*, and ſome more, to the *Weſtward* of the *Meridian* of the *Maderas*: But being in the *Latitude* near about we had eſpied the *Land*; and being becalmed, drove with the *Current* by the *Eaſtern* end of the *Iſland*, betwixt *Porto Sancto*, and the *Deſerts* or *Rocks* that lie off from that end. I compared *Reckoning* with moſt aboard each *Ship* that kept *Account*, and found ſome 30 *Leagues* to the *Weſtward* of the *Iſland*; and thereby in five *Voyages* made before that way, knew by Experience there is a *Current* ſets ſtrongly near about it *E. S. E.* Beſides, ſeveral *Ships* of *London* and the *Weſt-Country* have miſt it, after much labour and trouble to find it. *Snellius* inſtanceth, That one of good repute, ſailing out of *Holland* twice, miſt it and came home. I ſhall not here trouble you with more Inſtances, nor multiply needleſs Queſtions, nor ſtrive to branch them out in their ſeveral Varieties; but give you thoſe which are moſt uſeful and neceſſary: And then if my time will permit, I will ſhew you ſome *Arts* which will as much delight you to learn, and this as briefly as I can.

How we keep our Reckoning.

As for the firſt and moſt uſeful Queſtions in *Navigation*, is this; By the knowledge of the *Rhomb* or *Courſe* you ſailed upon, and the diſtance of *Miles* or *Leagues* that you ſailed thereon, to know your difference of *Latitude* and *Longitude* (that is, how much you are *Northerly* or *Southerly* in reſpect of *Latitude*, or *Eaſterly* or *Weſterly* in reſpect of *Longitude*.) This is the moſt ordinary manner of keeping of Account by moſt *Maſters* and *Mates*, of the *Ships* Way, which is called the *Dead Reckoning*. And to keep this *Account*, firſt you ſee, That the knowledge of the *Rhomb* they ſailed is always ſuppoſed to be had of the *Log-board*, ſuppoſing the *Compaſs* by which we ſteer, either doth or ſhould ſhew the ſame exactly; and ſo you have the *Diſtances* in *Miles* and *Leagues*, put down every half Watch upon the *Log-board*, with the *Courſe* ſailed, and Winds By or Large: Therefore we will come to the firſt *Queſtion*, and Reſolve it by the *Traverſe-Table* following, and alſo by the *Traverſe-Scale* in the *Fifth Chapter* of the *Second Book*. I have ſhewed by the *Sinical Quadrant* already, in the *Sixth Chapter* of the *Second Book*: And we will reſolve it alſo by the *Artificial Sines* and *Tangents* on the *Ruler*, and the *Tables*.

But know this, I never knew any *Courſe* ſteered at *Sea*, nearer than to half a *Point*; for there is no *Halfs* nor *Quarters* marked on the *Compaſs*.

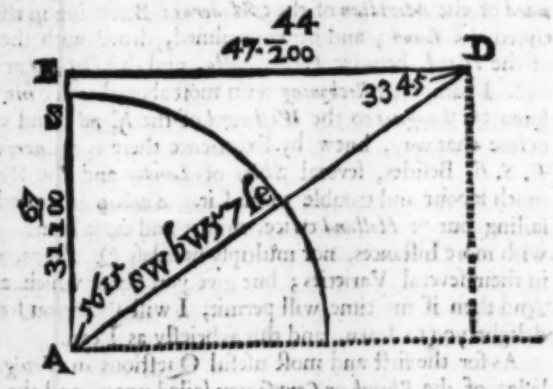
The First Propoſition.

Queſtions of *Sailing* by the Plain, Ordinary *Sea-Chart.*

I. *Sailing* 57 Leagues *upon the firſt* Rhomb, *How much ſhall I alter my* Parallel *of* Latitude?

THe *Angle* that any *Point* makes with the *Meridian*, we call the *Rhomb*; but the *Angle* that it makes with any *Parallel*, is called the *Complement* of the *Rhomb*. Unto every *Point* of the *Compaſs* there anſwers 11 *deg.* 15 *min.* therefore the fifth *Rhomb* from the *Meridian* makes *Angles* therewith of 56 *deg.* 15 *min.* namely, *S. W. b. W. S. E. b. E. N. W. b. W. N. E. b. E.* whoſe *Complement* 33 *deg.* 45 *min.* is the *Angle* of the ſame *Rhomb* with every *Parallel*.

Now admit I ſail from A to D, *S. W. b. W.* 57 *Leagues*, I demand the difference of *Latitude* E A.



Firſt, by the following *Traverſe-Table*, at the Head of the *Table*, over every *Column*, is put the *Figure* of Halfs, Quarters, and whole *Rhombs*; and in one of the *Columns* over head is *N. S.* and at the foot *E. W.* and ſo is numbred at the Head, from the left hand to the right. *N. S.* ſtands for *Northing*. Then the *Rhombs* are reckoned at the bottom, from the right hand back again; The *Margent* of the *Tables* ſhews the *Leagues* ſailed; and over *E. W.* or under *E. W.* ſhews how much you have ſailed *Eaſt* or *Weſt* from the *Meridian*. *N. S.* ſhews *North* or *South* from the *Latitude*. As in this *Example*, The diſtance ſailed is 57 *Leagues* on the fifth *Rhomb*; therefore under *Diſtance Sailed*, in the *Side*, I enter with 57 *Leagues*, and in the *Common Angle* or *Line* of *Meeting*, I find 31. $\frac{57}{100}$ over *N. S.* in the Foot; and in the next *Column*, over *E. W.* is 47. 39, as you ſee in the *Table* in the *Side*: So that the *Difference* of *Latitude* is 31 *Leagues* and $\frac{57}{100}$ *Parts* of a *League*. And if it were required to find the *Departure*, you ſee it to be 47 *Leagues* and $\frac{39}{100}$ *Parts*. This is very plain and eaſie, you need no farther *Precept*.

2 *Rhomb.*			
N	S	W	E
47	39	31	67
E	W	N	S
5 *Rhomb.*			

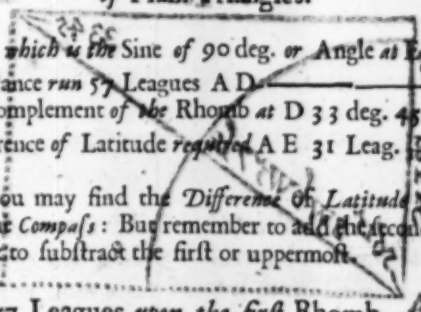
By the Traverſe-Scale.

EXtend the *Compaſſes* in the *Line* of *Numbers* from 100 to 57, the ſame Diſtance will reach from 5 *Points* to 31, and about $\frac{7}{10}$ in the *Line* of *Numbers*.

By the Artificial Sines *and* Numbers *on the* Ruler.

EXtend the *Compaſſes* from 100 in the *Line* of *Numbers*, to 57, as before; the ſame Diſtance will reach from the *Sine-Complement* of the *Rhomb*, to the *Difference* of *Latitude*, which is the ſame way as by the *Traverſe-Scale*.

By the Tables *of* Artificial Sines *and* Numbers, *by the* Fourth Caſe *of* Plain Triangles.



As the Radius, *which is the* Sine *of* 90 deg. *or* Angle at E ——— 1000000
Is to the Diſtance *run* 57 Leagues A D ——— 175587
So is the Sine-Complement *of the* Rhomb *at* D 33 deg. 45 min. — 974473
To the Difference *of* Latitude *required* A E 31 Leag. ——— 150060

In like manner you may find the *Difference of Latitude* for any *Diſtance* run upon any *Point* of the *Compaſs*: But remember to add the ſecond and third *Numbers* together, and from it to ſubſtract the firſt or uppermoſt.

II. *Sailing* 57 Leagues *upon the firſt* Rhomb, *How far am I departed from the* Meridian *of the Place from whence I came?*

By the Traverſe-Table.

THis *Queſtion* was anſwered in the laſt *Example*, and found over *E. W.* to be 47 *Leagues* and $\frac{19}{100}$, as you may ſee in the ſmall *Table* in the foregoing *Side*. In the like manner you may find the *Difference of Latitude* and departure from the *Meridian*, for any *Diſtance* run upon any *Point* of the *Compaſs*, which is the Uſe of that *Table*.

By the Traverſe-Scale.

EXtend the *Compaſſes* from 100 in the *Line* of *Numbers*, to the *Diſtance* run 57 *Leagues*; ſo is the *Sine* of the *Rhomb*; that is, put one *Point* of the *Compaſs* on 5 *Points*, in the *Line* of *Eaſt* and *Weſt* of the *Scale*, and the other will reach to the *Departure* from the *Meridian* 47 *Leagues* $\frac{19}{100}$ *Parts*.

By the Tables *of* Sines *and* Numbers, *by the* Fourth Caſe *of* Plain Triangles.

As the Radius *or* Sine *of* 90 deg. *at* E ——— 1000000
Is to the Diſtance *run* 57 Leagues A D ——— 175587
So is the Sine *of the* Rhomb 56 deg. 15 min. A ——— 991084
To the Departure *from the* Meridian *to* 47 $\frac{19}{100}$ E D ——— 166671

By the Artificial Lines *on the* Ruler.

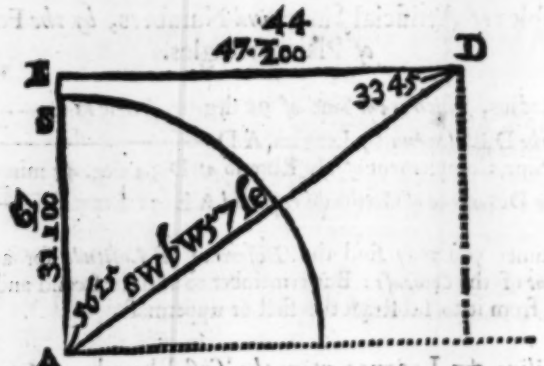
EXtend the *Compaſſes* from 90 *deg.* to 57; the ſame *Diſtance* will reach from 56 *deg.* 15 *min.* to 47 $\frac{19}{100}$ *Leagues*.

Or, Extend the *Compaſſes* from 90, to 56 *deg.* 15 *min.* the ſame Diſtance will reach from 57 *Leagues*, to 47 $\frac{19}{100}$, as before.

III. *Sailing*

III. *Sailing upon the fifth* Rhomb, *until I alter my* Latitude 1 deg. 35 min. *I demand how far I have Sailed?*

AS ſailing from A to C, *S. W. b. W.* till the *Difference* of *Latitude* be 31 *Leagues* $\frac{67}{100}$, I demand the *Diſtance* run A C.



Firſt, By the *Traverſe-Table*, Look in the Foot of the *Table* for the fifth *Rhomb*, and over *N. S.* in that *Column*, look for 31 *Leagues* $\frac{67}{100}$, and in the *Common Angle of Meeting*, to the left hand, under *Diſtance Sailed*, you will find *Diſtance Sailed* 57 *Leagues* A C required.

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from the *Complement-Sine* 33 *deg.* 45, to 31 $\frac{67}{100}$ the *Difference* of *Latitude*; the ſame Extent will reach from 90 *deg.* to 57 *Leagues.*

Or, Extend the *Compaſſes* from 33 *deg.* 45 *min.* to 90; the ſame *Diſtance* will reach from 31 $\frac{67}{100}$ *Leagues*, to 57 *Leagues*, the *Diſtance* A C, as before.

Say by the ſecond *Caſe* in *Plain Triangles*,

As the Sine-Complement *of the* Rhomb, 33 deg. 45	9.744739
Is to the Difference *of* Latitude 31 $\frac{67}{100}$ Leagues	3500648
So is the Sine *of* 90 deg. Radius	10000000
To the Diſtance *run* A C 57 $\frac{67}{100}$ Leagues	3755909

IV. *Sailing upon the fifth* Rhomb, *until I have altered my* Latitude 31 $\frac{67}{100}$ *or* 1 deg. 35 min. *How much am I departed from my firſt* Meridian?

AS ſailing from A to C, *S. W. b. W.* till the *Difference* of *Latitude* A B be 31 $\frac{67}{100}$ *Leagues*, I require B C my departure from my *Meridian.*

By the Traverſe-Table.

AS in the laſt *Caſe*, find 31 $\frac{67}{100}$ *Leagues* over the fifth *Rhomb*, in the Foot, and in the next *Column* to the left hand, over *E. W.* is 47 $\frac{19}{100}$ *Leagues*, the *Departure* required.

By

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from the *Complement-Line* of the *Rhomb*, to 33 *deg.* 45, to 31 $\frac{67}{100}$ *Leagues*; the ſame *Diſtance* will reach from 56 *deg.* 15 *min.* the *Sine* of the *Rhomb*, to 47 $\frac{19}{100}$ *Leagues*, the *Departure* from the *Meridian*.

By the fourth Caſe *of* Plain Triangles.

As the Sine *of* 90 deg. —— 10000000
To the Difference *of* Latitude A B 31 $\frac{67}{100}$ —— 2501059
So is the Tangent *of the* Rhomb 56 deg. 15 —— 10175107
To the Departure *from the* Meridian 47 $\frac{19}{100}$ *Leagues* —— 2676166

In the like manner, by the *Departure* from the *Meridian*, you may find the *Difference* of *Latitude*.

V. *Sailing upon ſome* Rhomb *between the* South *and the* Weſt 57 Leagues, *and finding I have altered my* Latitude 1 deg. 35 m. *I demand upon what* Point *I have ſailed.*

SUppoſe I had ſailed from A to C (being a *Rhomb* between the *Weſt* and *South*) 57 *Leagues*, and then find the *Difference* of *Latitude* 31 $\frac{67}{100}$ *Leagues*, I demand the *Angle* B A C.

By the Traverſe-Table.

NUmber 57 *Leagues* in the *Column* of *Diſtance Sailed*, and in that *Line* or *Common Angle* of *Meeting*, you muſt find the *Difference* of *Latitude* 31 $\frac{67}{100}$ *Leagues*, at the Foot of the *Table* in the fifth *Rhomb*, which was required.

By the Line *of* Sines *and* Numbers *on the* Scale.

EXtend the *Compaſſes* from the *Diſtance* run 57 *Leagues*, to the *Sine* of 90; the ſame *Diſtance* will reach from the *Difference* of *Latitude*, to the *Sine-Complement* of the *Rhomb* 33 *deg.* 45 *min.*

By the fifth Caſe *of* Plain Triangles.

OR, Open the *Compaſſes* from 57 *Leagues* the *Diſtance*, to 31 $\frac{67}{100}$ the *Difference* of *Latitude*; the ſame *Diſtance* will reach from the *Sine* of 90, to the *Sine* of 33 *deg.* 45 *min.* the *Sine-Compl. Rhomb.*

As the Diſtance *on the* Rhomb A C 57 Leagues —— 2755874
Is to the Difference *of* Latitude 31 $\frac{7}{100}$ Leagues A B —— 2501059
So is the Sine *of* 90 deg. B —— 10000000
To the Compl. Sine *of the* Rhomb *at* C 33 d. 45 m. *the* Sum — 12501059
The firſt Number *ſubſtract* —— 2755874
The Sine *of the* Angle —— 9745185

The *Sine-Complement* of the *Rhomb* is C 33 *deg.* 45, ſubſtracted from 90 *degrees*, there remains the *Angle* of the *Rhomb* at A 56 *deg.* 15 *min.* which is five *Points*, namely, *S. W. b. W.* We neglect ſome part of a *Minute*, which is not to be regarded.

VI. *Sailing*

VI. *Sailing upon ſome* Rhomb *between the* South *and the* Weſt 57 Leagues, *and finding I have altered my* Latitude 1 deg. 35 min. *I demand my* Departure *from my firſt* Meridian.

By the Traverſe-Table.

NUmber 57 *Leagues* in the *Column* of *Diſtance Sailed*, and in that *Line* or *Angle* of *Meeting* find $31\frac{67}{100}$. *Leagues*, and in the *Column* to the left hand you will have $47\frac{32}{100}$. the *Departure* from the *Meridian*.

By the Sixth Caſe *of* Plain Triangles.

Diſtance *run* A C 57 Leagues } Sum 88 Leagues ——— 2947923
Diff. *of* Lat. A B $31\frac{67}{100}$. Leagues } Remain $26\frac{7}{10}$. Leagues ——— 2424881
5372804
Departure *from the* Meridian B C $47\frac{3}{4}$ Leagues ——— 2681402

This is thus done. To the *Diſtance* run, add the *Difference* of *Latitude*, and alſo ſubſtract it from the ſame, noting the *Sum* and *Remainder*; then add together the *Logarithm* of this *Sum* and *Remain*, and half that is the *Logarithm* of the *Diſtance* from the firſt *Meridian*.

By the Line *of* Numbers.

EXtend the *Compaſſes* from the *Diſtance* 57 *Leagues*, to $31\frac{3}{4}$ the *Difference* of *Latitude*; the ſame Diſtance will reach from 88 the *Sum*, to the *Departure*, as before, $47\frac{3}{4}$ *Leagues*.

Or, Extend the *Compaſſes* from 57, to the *Sum* $88\frac{3}{4}$ *Leagues*; the ſame Diſtance will reach from $31\frac{3}{4}$, to $47\frac{3}{4}$, as before, which is the *Departure* required.

All things that have been done by the *Artificial Lines* and *Numbers*, are done by the *Traverſe-Scale*, or *Artificial Points*, *Halfs*, and *Quarters*, and *Tangent-Rhombs*, with the *Line* of *Numbers* in the *Traverſe-Table*; and this agreeing very well in *Leagues* and 100 *Part* of a *League*.

Chap. II.

What muſt be obſerved by all that keep Account *of a* Ship's Way *at* Sea; *And to find the true* Point *of the* Ship *at any time, according to the* Plain Chart.

I Might have further inlarged and multiplied *Queſtions*, but that I think theſe ſufficient for any Uſe at preſent; and therefore I will be brief, and come to the moſt material Buſineſs, (*viz.*)

The whole *Practice* of the *Art* of *Navigation*, in keeping of a right *Reckoning*, conſiſts chiefly of three *Members* or *Branches*.

Firſt, Well experienced in Judgment, in eſtimating the *Ship's Way* in her *Courſe* upon every ſhift of *Wind*; allowing for *Leeward-way*, and *Currents*.

Secondly, In duly eſtimating the *Courſe* or *Point* of the *Compaſs* on which the *Ship* hath made her *way* good; allowing for *Currents*, and the *Variation* of the *Compaſs*.

Thirdly, The diligent taking all Opportunities of due obſerving the *Latitude*.

The *Reckoning* ariſing out of the two firſt *Branches*, we call our *Dead Reckoning*; and of theſe *Branches* there ought to be ſuch an Harmony and Concent, that any

two

two being given, as you ſee by the *Work* before-going, a third *Concluſion* may thence be raiſed with Truth.

As, Having the *Courſe* and *Diſtance*, to find the *Latitude* of the *Ship's Place*.

Or, By the *Courſe* and *Difference* of *Latitude*, to find the *Diſtance*:

Or, By the *Difference* of *Latitude* and *Diſtance*, to find the *Courſe*.

But in the midſt of ſo many Uncertainties that daily occur in the Practice of *Navigation*, a joynt Conſent in the three *Particulars*, is hardly to be expected; and when an Error ariſeth, the ſole Remedy to be truſted to, is the Obſervation of the *Latitude*, or the known *Soundings* when a *Ship* is near *Land*: and how to rectifie the *Reckoning* by the obſerved *Latitude*, we ſhall ſhew.

I would adviſe all *Sea-men* to yield unto Truth in this particular, That about 24 of the common *Engliſh Sea-Leagues*, are to be allowed to vary a *Degree* of *Latitude*, Sailing due *North* or *South*, under the *Meridian*; otherwiſe they put themſelves to many Uncertainties in their *Accounts*.

Firſt, In Sailing directly *North* or *South*, where there is no *Current*, finding their *Reckoning* to fall ſhort of the obſerved *Latitude*, they take it to be an Errour in their Judgement, in concluding the *Ship's Way* by eſtimation or gueſs to be too little.

And ſecondly, If there be a *Current* that helps ſet them forward, that there is a neer agreement between the obſerved and the *Dead Latitude*, they conclude there is no ſuch *Current*.

Or laſtly, If they ſtem the *Current*, they conclude it to be much ſwifter than in truth it is: And thus one Error commonly begets another. But ſuppoſing a Conformity to the Truth, we ſhall preſcribe four *Rules* for correcting a *Single Courſe*.

THE LOG-BOARD.



Hours.	*Courſe.*	*Knots.*	*Half Knots.*	*Fathoms.*	*By or large.*
2	S. E. b. S.	7	½	2	L
4	S. S. W.	6	½		L
6	E. b. N.	9			L
8	N. b. E. ½ E.	8			L
10	N. N. W. ½ W.	7	½		L
12	W. N. W.	9			L
2	S. E. b. S.	8	½	2	L
4	S. S. W.	7	½		L
6	S. W. b. S.	6			L
8	S. W.	9			L
10	S. E.	8	½	3	B
12	S. E.	9			B

But firſt of all it is moſt neceſſary to ſhew how we do keep our *Reckonings* at *Sea*, by the *Log-board*, and alſo by our *Journal-Book*.

The firſt *Column* is for *Time*.

The ſecond for the *Ship's Courſe*.

The third for the *Knots*.

The fourth for the *Half Knots*.

The fifth for the *Fathoms*.

The ſixth is to put down the Sailing *Large*; that is, to make her *Way* good on the *Point* ſhe Sails, ſignified by *L*; and Sailing *By* the *Wind*, ſignified by *B*; that is, to give allowance to your *Courſe* according to the *Lee-way* you have made (by taking in or having out more Sail, or by *Currents* or *Variation*) thoſe ſeveral Diſtances

Our *Engliſh* or *Italian Mile* by which we reckon at *Sea*, contains 1000 *Paces*, and each *Pace* 5 *Foot*, and every *Foot* 12 *Inches*; the 120 part of that *Mile* is 41 ½ *Feet*, and ſo much is the ſpace between the *Knots* upon the *Log-line*: ſo many

Knots as the *Ship* runs in half a *Minute*, ſo many *Miles* ſhe Saileth in an *Hour*; or ſo many *Leagues* and ſo many *Miles* ſhe runneth in a *Watch*, which is four *Hours*, the time in which half the *Company* belonging to the *Ship* watcheth at once by turns.

EXAMPLE.

Nine *Knots* in half a *Minute*, is nine *Miles* in an *Hour*, which is nine *Leagues* and nine *Miles* in a *Watch*, which is 12 *Leagues* or 36 *Miles* in all. Every *Noon*, after the *Maſter Mates* having obſerved the *Sun's Altitude*, or every *Day* at *Noon*, they take the *Reckoning* from the *Log-board*, and double the *Knots* run, and then divide the *Product*, which is the number of *Miles* run, by three; the *Quotient* is the *Leagues* run ſince the former *Noon*. Or elſe add up the *Knots*, and multiply them by 2, and divide by 3, you have the ſame: But be ſure it is all upon *Courſe*. We throw the *Log* every two *Hours*, and we never expreſs the *Courſe* nearer than ½ a *Point* of the *Compaſs*.

Mr. *Norwood* gives full ſatisfaction in his *Seaman's Practice*, by his own experience, That in our ordinary Practice at *Sea*, we cannot, if we will yield Truth the Conqueſt, allow leſs than 360000 of our *Engliſh Feet* to vary one *Degree* of *Latitude* upon the *Earth*, in ſailing *North* or *South* under any *Meridian*. According to this Meaſure, there will be in a *Degree* 68 2/11 of *Miles* of our *Statute-meaſure*, each *Mile* 5280 *Feet*; and by the common *Sea-meaſure*, 5000 *Feet* to a *Mile*, there will be 72 *Miles* or 24 *Leagues* in a *Degree*, which we will take for truth.

Now if you would have ſhewn the *Miles* of a true *Degree*, allowing 60 to a *Degree*, the *Miles* muſt be enlarged proportionally, and the diſtance between every one of the *Knots* muſt be 50 *Foot*; as many of theſe as run out in half a *Minute*, ſo many *Miles* or *Minutes* the *Ship* ſaileth in an *Hour*; and for every *Foot* more, you muſt allow the 10 part of a *Mile*. And ſo, if you will work the old way by *Leagues*, you muſt reduce them by *Arithmetick* into a *Degree*, and 100 parts of a *Degree*; or *Miles* or *Minutes* may ſerve. For I have ſeen no *Chart* that the *Meridian* is divided into more parts than 6 times 10, which is 60 *Minutes*; or *Mercator's Chart* 20 times 3, which is 60: So the ſmall *Diviſions* on the *Dutch Mercator's Charts*, every 3 is a *Mile* or *Minute*, which is near enough for any uſe at *Sea*; and theſe *Degrees* are not above ½ an *Inch* upon the *Æquator*.

Sailing *Eaſt* or *Weſt* berween any two Places, and uſing a *Log-line* that hath a *Knot* at every 7 *Fathoms*, and to reduce it into ſuch *Miles* 60 to a *Degree*, each containing 6000 *Feet*, the *Proportion* in *Number* of theſe two is this, *As 6 to 5*; for 6 *Knots* of 7 *Fathoms* makes 5 of 8 2/7 *Fathom*, or 50 *Feet*. Admit a Man keeps a *Reckoning* of his *Ship* by a *Log-line* of 7 *Fathoms*, and by it find the diſtance of two Places 1524 *Miles*, or 508 *Leagues*, and would know the diſtance by a *Log-line* of 50 *Feet* to a *Knot*, or 6000 *Feet* to a *Mile*: Say then by the *Rule* of *Proportion*, *As 6 is to 5*: *So is* 1524 *to* 1720 *Miles*, whereof 60 *Miles* make a *Degree* or 20 *Leagues*.

Next we will work the *Courſes* of the *Log-board*, and by it find the difference of *Latitude*, and departure from the firſt *Meridian*.

A *Ship* being in the *Latitude* of 47 *deg.* 30 *min. North*, and *Longitude* 00 *degrees*, the firſt *Courſe* of the *Log-board* is *S. E. b. S.* 16 *Miles*, and *S. S. W.* 13 *Miles*, *E. b. N.* 18 *Miles*, and *N. b. E.* ½ *E.* 16 *Miles*, *N. N. W.* ½ *W.* 15 *Miles*, and *W. N. W.* 18 *Miles*, and *S. E. b. S.* 18 *Miles*, and *S. S. W.* 15 *Miles*, *S. W. b. S.* 12 *Miles*, and *S. W.* 18 *Miles*, *S. E.* 18 *Miles* by the *Wind*, the *Wind* at *W. S. W.* and *E. S. E.* The *Ship* made two *Points Lee-way* on the two laſt *Courſes*.

I demand the *Difference* of *Latitude*, and departure from the *Meridian* the laſt 24 *Hours*, and the *Latitude* I am in.

There are ſeveral ways to work *Traverſes*; but the moſt neceſſary and readieſt is by the *Traverſe-Scale*, and the following *Table*; the firſt is to the 10 *part* of a *League*, and the *Table* to the 100 *part* of a *League* or *Mile*. We ſhall work the former *Traverſe* by the *Tables* following, and you at leiſure may work it by the *Traverſe-Scale*, and find the neer agreement of both without any ſenſible Error.

You

Course by Compass.	*Miles sailed.*	*North.* Miles.	100.	*South.* Miles.	100.	*East.* Miles.	100.	*West.* Miles.	100.
S. E. b. S.	16			13	30	08	89		
S. S. W.	13			12	01			04	97
E. b. N.	18	03	51			17	65		
N. b. E. ½ E.	16	15	31			04	64		
N. b. W. ½ W.	15	13	23					07	07
W. N. W.	18	06	89					16	63
S. E. b. S.	18			14	97	10	00		
S. S. W.	15			13	86			05	74
S. W. b. S.	12			09	98			06	67
S.W: W.S.W.	18			06	89			16	63
S.E: E.S E.	18			06	89	16	63		
Sum of all		38	94	77	90	57	81	57	61
Substract leaſt				38	94	57	61		
Remains differ. Latitude.				38	96	00	20		

11 *Differ. South and East.*

The Latitude *the* Ship *is in is* 46 d. 49 m. *The* Course *made is* South *almoſt.*

You muſt put down the *Courſes* made good upon each *Point* of the *Compaſs*, and the number of *Miles* or *Leagues* you find ſailed on them by the *Log-board*; in ſuch manner as I have done in this *Table*: then according to the *Rhombs*, look in the *Table* following for the *Point*, *Half*, or *Quarter* ſailed, and the Diſtance in *Miles* or *Leagues*, in the right hand or left hand *Column*; and count the four *Points* and *Quarters* in the head of the *Table*, and the four next the *Eaſt* and *Weſt*, from the left hand to the right hand, in the foot of the *Table*.

Put down in four *Columns N. S. E. W.* and under put what anſwers each *Point*.

As for Example. The firſt *Courſe* ſailed is three *Points* from the *Meridian*; namely, *S. E. b. S.* under that *Column* I count 16 *Miles* in the ſide, and find againſt it 13 $\frac{30}{100}$ *Miles Southing*, and 8 $\frac{89}{100}$ *Miles Eaſting*. I put it down in the *Table* in its place, 13. 30 under *South*, 8. 89 under *Eaſt*. In the like manner you muſt do by the reſt. Likewiſe the laſt *Courſe* ſailed *S. E.* but by reaſon of 2 *Points Leeward-way*, it is but *E. S: E.* that is, 6 from the *South*; therefore I reckon them in the Foot of the *Table*, and right againſt 18 I find 06. 89 *Southward*, and 16. 63 *Eaſtward*, which you may put down as I have done in the *Table*. In the like manner you muſt do if your *Courſe* were *North* or *Weſting*. This is ſo plain it needs no farther *Precept*.

Then add up the *Sums* in each *Column*, and ſubſtract the leſſer out of the greater, the Remainer is the *Difference* of *Latitude* and *Departure*: As I find that the *Ship* hath gone but 38 $\frac{96}{100}$ *Miles* to the *Southward*, and the *Latitude* ſhe now is in is 46 *deg.* 49 *min.* and the *Eaſtward* but 20 *parts* of 100 of a *Mile*: Therefore her *Courſe* is neer *South* ſhe made good the laſt 24 *Hours*.

CHAP. III.

A Formal and Exact Way of Setting down and Perfecting a Sea-Reckoning.

The Rule of keeping a perfect Sea-Reckoning is beſt ſet down in particular after the general true Sea-Chart, in Chap. 17. of Great Circle Sailing.

THis being the moſt neceſſary *Rule* in this *Art* of *Navigation*, How to keep an *Exact Reckoning*; Although the *Courſe* and *Diſtance* cannot be ſo truly and certainly known, as the *Latitude* may be; yet we muſt endeavour in theſe alſo to come as neer the truth as may be; the rather, for that ſome *Reckonings* muſt neceſſarily depend wholly upon them. Therefore we come now to ſhew an Orderly and Exact way of Framing and Keeping a *Reckoning* at *Sea*; for which purpoſe I have inſerted this *Table* following, which ſheweth how much a *Ship* is more *Northerly* or *Southerly*, and how much *Eaſterly* or *Weſterly*, by ſailing upon any *Point*

or *Quarter-point* of the *Compaſs*, any diſtance or number of *Miles* or *Leagues* propoſed.

Mr. *Norwood* many *Years* ſince laid the ground of making this *Table*, after this Proportion, [*As* Radius *is in Proportion to* Diſtance *run*: *So is the* Sine-Complement *of the* Rhomb, *to the* Diſtance *of* North *or* South: *And ſo is the* Sine *of the* Rhomb *to the* Diſtance *of* Eaſt *or* Weſt] as you may ſee by the firſt and ſecond *Caſe* of *Plain Triangles*.

Therefore for every *Point* and *Quarter-point* from the *Meridian*, there are four *Columns*: In the firſt thereof is ſet down the number of *Leagues* or *Miles* run or ſailed upon that *Point* or *Quarter-point* of the *Compaſs*; The ſecond ſheweth how much you have altered the *Latitude*, that is, how much you are more *Southerly* or *Northerly*, by running ſo far upon that *Point* or *Quarter-point*; The third ſheweth how much you are more *Eaſterly* or *Weſterly*, by running or ſailing that *Courſe* and *Diſtance*, as you have been before directed.

Note this, The *Numbers* ſet in the firſt *Column* from 1 to 10, are alſo to be underſtood from 10 to 100, or from 100 to 1000: and the *Figure* of the fourth place anſwers to the *Figure* in the firſt.

As, Suppoſe a *Ship* ſails away *South* $\frac{1}{2}$ a *Point Weſterly* 173 *Leagues* or *Miles*; we ſet down this *Number* thus. Look into the firſt *Column* for the $\frac{1}{2}$ *Point*, or $\frac{1}{2}$ the firſt *Rhomb* from the *Meridian* againſt 10 is ſometimes made uſe of, and underſtood to be 100. I find in the ſecond *Column* againſt it 995 (or you may have the ſame *Number* at 100 towards the *Foot* of the *Table*, omitting the laſt *Figure*) and then in the third *Column* you may ſee 98; alſo againſt 70, or 7, there is 697, and in the ſecond 68; and in the third againſt three in the firſt *Column* is 29, in the ſecond is 2 and $\frac{9}{100}$, which is almoſt $\frac{1}{10}$; therefore I put down 3.

Courſe	*Diſtance.*	*Southing.*	*Weſting.*
South	100	995	98
$\frac{1}{2}$ *Po.* W.	70	697	68
	3	29	3
Leagues.	173	1721	168

Theſe ſummed up as in the *Table*, ſhews that the *Ship* ſailing upon the firſt half *Point* from the *Meridian*, as namely, *S.* $\frac{1}{2}$ *W.* is to the *Southwards* of the Place ſhe departed 172 $\frac{1}{10}$ *Leagues* or *Miles*, and to the *Weſtward* 16 *Leagues* and $\frac{8}{10}$. If you deſire more Exactneſs, you may uſe all the Places for the greateſt *Number*, which is 100, (*viz.*)

A Traverſe-Table

A Traverse-Table for every Point, Half-Point, and Quarter-Point of the Compass, to the 100 part of a League or Mile; which gives the Difference of Lat. and Departure from the Meridian.

The *Traverse-Table*, The 1 Points Quarter.

Distance Leagues or Miles sail'd	2 deg. 49 m. 0 Point ¼				5 deg. 38 m. 0 Point ½				8 deg. 26 m. 0 Point ¾				11 deg. 15 m. 1 Point.				Dist. in Leagues or Miles sail'd
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	01	00	00	05	01	00	00	10	00	98	00	14	00	98	00	20	1
2	02	00	00	10	01	99	00	20	01	97	00	29	01	96	00	39	2
3	03	00	00	15	02	98	00	29	02	96	00	44	02	94	00	58	3
4	04	00	00	20	03	98	00	39	03	95	00	58	03	92	00	78	4
5	04	09	00	25	04	97	00	49	04	94	00	73	04	90	00	93	5
6	05	09	00	29	05	97	00	59	05	93	00	88	05	88	01	17	6
7	06	09	00	34	06	97	00	69	06	92	01	02	06	86	01	37	7
8	07	09	00	39	07	96	00	78	07	91	01	17	07	85	01	56	8
9	08	09	00	44	08	96	00	88	08	90	01	32	08	83	01	76	9
10	09	09	00	49	09	95	00	98	09	89	01	46	09	81	01	95	10
11	10	98	00	54	10	95	01	08	10	88	01	61	10	79	02	15	11
12	11	98	00	59	11	94	01	18	11	87	01	76	11	77	02	34	12
13	12	98	00	63	12	94	01	27	12	86	01	91	12	75	02	54	13
14	13	98	00	68	13	93	01	37	13	85	02	05	13	73	02	73	14
15	14	98	00	73	14	93	01	47	14	84	02	20	14	71	02	19	15
16	15	98	00	78	15	92	01	57	15	83	02	34	15	69	03	12	16
17	16	98	00	83	16	92	01	67	16	82	02	49	16	67	03	32	17
18	17	97	00	88	17	91	01	76	17	80	02	64	17	65	03	51	18
19	18	97	00	93	18	91	01	86	18	79	02	79	18	64	03	71	19
20	19	97	00	98	19	90	01	96	19	78	02	93	19	62	03	90	20
21	20	97	01	03	20	90	02	06	20	77	03	08	20	60	04	10	21
22	21	97	01	08	21	98	02	16	21	76	03	22	21	58	04	29	22
23	22	97	01	13	22	89	02	25	22	75	03	37	22	56	04	49	23
24	23	97	01	17	23	88	02	35	23	74	03	51	23	54	04	68	24
25	24	97	01	22	24	88	02	45	24	73	03	66	24	52	04	88	25
26	25	96	01	27	25	87	02	55	25	71	03	81	25	50	05	07	26
27	26	96	01	32	26	87	02	65	26	70	03	96	26	48	05	27	27
28	27	96	01	32	27	86	02	75	27	69	04	10	27	46	05	46	28
29	28	96	01	42	28	86	02	84	28	68	04	25	28	44	05	66	29
30	29	96	01	47	29	86	02	94	29	67	04	40	29	42	05	85	30
31	30	96	01	52	30	85	03	04	30	66	04	55	30	40	06	05	31
32	31	96	01	57	31	85	03	14	31	65	04	69	31	38	06	24	32
33	32	96	01	61	32	84	03	23	32	64	04	84	32	37	06	44	33
34	33	95	01	66	33	84	03	33	33	63	04	98	33	35	06	63	34
35	34	95	01	71	34	83	03	43	34	62	05	13	34	33	06	83	35
36	35	95	01	75	35	83	03	53	35	61	05	28	30	31	07	02	36
37	36	95	01	81	36	82	03	63	36	60	05	42	36	29	07	22	37
38	37	95	01	86	37	82	03	73	37	59	05	57	37	27	07	41	38
39	38	95	01	91	38	81	03	82	38	58	05	72	38	25	07	61	39
40	39	95	01	96	39	81	03	92	39	57	05	87	39	23	07	80	40
41	40	95	02	01	40	80	04	02	40	55	06	02	40	21	08	00	41
42	41	95	02	06	41	80	04	12	41	54	06	16	41	19	08	19	42
43	42	95	02	11	42	79	04	21	42	15	06	31	42	17	08	39	43
44	43	94	02	15	43	79	04	31	43	52	06	45	43	15	08	58	44
45	44	94	02	20	44	78	04	41	44	51	06	60	44	14	08	78	45
46	45	94	02	25	45	78	04	51	45	60	06	75	45	12	08	77	46
47	46	94	02	30	46	77	04	61	46	49	06	89	46	10	09	17	47
48	47	94	02	35	47	77	04	70	47	48	07	04	47	08	09	36	48
49	48	94	02	40	48	76	04	80	48	47	07	20	48	06	09	56	49
50	49	94	02	45	49	76	04	90	49	46	07	33	49	04	09	75	50
51	50	93	02	50	50	75	05	00	50	44	07	48	50	02	09	95	51
52	51	93	02	55	51	75	05	10	51	43	07	63	51	00	10	14	52
53	52	93	02	60	52	74	05	20	52	42	07	77	51	98	10	34	53
54	53	93	02	65	53	74	05	29	53	41	07	92	52	96	10	53	54
55	54	93	02	70	54	73	05	39	54	40	08	07	53	94	10	73	55
56	55	93	02	75	55	73	05	49	55	30	08	21	54	92	10	92	56
57	56	93	02	79	56	72	05	59	56	38	08	36	55	90	11	12	57
58	57	93	02	84	57	72	05	68	57	37	08	51	56	89	11	31	58
59	58	92	02	89	58	71	05	78	58	36	08	65	57	87	11	51	59
60	59	92	02	94	59	71	05	88	59	35	08	80	58	85	11	70	60
70	69	91	03	43	69	66	06	86	69	24	10	27	68	65	13	65	70
80	79	90	03	92	79	61	07	84	79	13	11	73	78	46	15	60	80
90	89	89	04	41	89	56	08	82	89	02	13	20	88	27	17	55	90
100	99	87	04	90	99	51	09	80	98	91	14	67	98	08	19	50	100
200	199	76	09	80	199	02	19	60	197	82	29	34	196	16	39	00	200

E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S
7 Point ¾				7 Point ½				7 Point ¼				7 Point.			
87 deg. 11 m.				84 deg. 22 m.				81 deg. 34 m.				78 deg. 45 m.			

The 7 Points Quarters.

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile; *which gives the* Difference *of* Lat. *and* Departure *from the* Meridian.

The *Traverse-Table*, The 2 Points Quarter.

Dist. in Leagues or Miles sail'd	14 deg. 04 m. — 1 Point ¼				16 deg. 52 m. — 1 Point ½				19 deg. 41 m. — 1 Point ¾				22 deg. 30 m. — 2 Points.				Dist. in Leagues or Miles sail'd
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	00	97	00	24	00	96	00	29	00	94	00	33	00	92	00	38	1
2	01	94	00	48	01	91	00	58	01	88	00	67	01	85	00	76	2
3	02	91	00	72	02	87	00	87	02	82	01	01	02	77	01	75	3
4	03	88	00	97	03	83	01	16	03	77	01	34	03	70	01	53	4
5	04	85	01	21	04	78	01	45	04	73	01	68	04	62	01	91	5
6	05	82	01	45	05	74	01	74	05	65	02	02	05	54	02	30	6
7	06	79	01	70	06	70	02	03	06	59	02	35	06	47	02	68	7
8	07	76	01	94	07	66	02	32	07	53	02	70	07	39	03	16	8
9	08	73	02	18	08	61	02	61	08	47	03	03	08	31	03	44	9
10	09	70	02	43	09	57	02	90	09	41	03	37	09	24	03	83	10
11	10	67	02	67	10	53	03	19	10	36	03	71	10	16	04	21	11
12	11	64	02	91	11	48	03	48	11	30	04	04	11	09	04	59	12
13	12	61	03	15	12	44	03	77	12	24	04	36	12	01	04	97	13
14	13	58	03	40	13	40	04	06	13	18	04	72	12	93	05	36	14
15	14	55	03	64	14	35	04	35	14	12	05	05	13	86	05	74	15
16	15	52	03	88	15	31	04	64	15	06	05	39	14	76	06	12	16
17	16	49	04	13	16	27	04	93	16	00	05	73	15	71	06	51	17
18	17	46	04	37	17	22	05	22	16	95	06	06	16	63	06	89	18
19	18	43	04	61	18	18	05	51	17	89	06	40	17	55	07	27	19
20	19	40	04	86	19	14	05	81	18	83	06	74	18	48	07	65	20
21	20	37	05	10	20	10	06	10	19	77	07	08	19	40	08	04	21
22	21	34	05	34	21	05	06	39	20	71	07	41	20	32	08	42	22
23	22	34	05	48	22	01	06	68	21	66	07	75	21	25	08	80	23
24	23	28	05	83	22	97	06	97	22	60	08	08	22	17	09	18	24
25	24	25	06	07	23	91	07	26	23	54	08	42	23	10	09	57	25
26	25	22	06	31	24	88	07	55	24	48	08	76	24	02	09	95	26
27	26	19	06	56	25	84	07	84	25	42	09	10	24	94	10	33	27
28	27	16	06	80	26	79	08	13	26	36	09	43	25	87	10	71	28
29	28	13	07	04	27	75	08	42	27	30	09	77	26	79	11	10	29
30	29	10	07	28	28	71	08	71	28	25	10	11	27	72	11	48	30
31	30	07	07	53	29	66	09	00	29	19	10	44	28	64	11	86	31
32	31	04	07	77	30	62	09	29	30	13	10	74	29	56	12	25	32
33	32	01	08	01	31	58	09	58	31	07	11	12	30	49	12	63	33
34	32	98	08	26	32	54	09	87	32	01	11	45	31	44	13	01	34
35	33	95	08	50	33	49	10	16	32	95	11	79	32	34	13	39	35
36	34	92	08	74	34	45	10	45	33	89	12	13	33	26	13	78	36
37	35	80	08	99	35	41	10	74	34	84	12	47	34	18	14	16	37
38	36	26	09	23	36	36	11	03	35	78	12	80	35	11	14	54	38
39	37	83	09	47	37	32	11	32	36	72	13	14	36	03	14	92	39
40	38	80	09	71	38	28	11	61	37	66	13	48	36	96	15	31	40
41	39	77	09	96	39	23	11	90	38	60	13	81	37	88	15	69	41
42	40	74	10	20	40	19	12	19	39	34	14	15	38	80	16	07	42
43	41	71	10	44	41	15	12	48	40	49	14	49	39	73	16	45	43
44	42	68	10	69	42	12	12	77	41	43	14	72	40	65	16	84	44
45	43	65	10	63	43	06	13	06	42	37	15	16	41	57	17	22	45
46	44	62	11	17	44	62	13	35	43	41	15	50	42	50	17	60	46
47	45	59	11	42	44	98	13	64	44	25	15	83	43	42	17	99	47
48	46	56	11	66	45	95	13	93	45	19	16	17	44	35	18	37	48
49	47	33	11	90	46	89	14	22	46	13	16	37	45	27	18	75	49
50	48	50	12	14	47	85	14	51	47	08	16	85	46	19	19	13	50
51	49	47	12	39	48	80	14	80	48	01	17	18	47	12	19	52	51
52	50	44	12	63	49	76	15	09	48	96	17	31	48	04	19	89	52
53	51	41	12	87	50	72	15	38	49	90	17	85	48	97	20	28	53
54	52	38	13	12	51	67	15	67	50	84	18	19	49	85	20	66	54
55	53	35	13	36	52	63	15	96	51	78	18	53	58	01			55
56	54	32	13	60	53	59	16	26	52	73	18	87	51	73	21	15	56
57	55	29	13	85	54	55	16	55	53	67	19	20	52	66	21	43	57
58	56	26	14	09	55	50	16	84	54	61	19	54	53	58	22	81	58
59	57	23	14	33	56	46	17	23	55	55	19	87	54	21	22	20	59
60	58	20	14	57	57	42	17	42	56	49	20	21	55	43	22	58	60
70	67	90	17	00	66	90	20	31	65	90	23	58	64	67	26	78	70
80	77	60	19	43	76	55	23	22	75	32	26	95	73	91	30	61	80
90	87	30	21	86	86	10	26	12	84	73	30	39	83	14	34	44	90
100	97	00	24	29	95	69	29	02	94	15	33	68	92	38	38	26	100
200	194	00	48	58	191	38	58	04	188	30	67	36	184	76	76	52	200
	E W N S — 6 Points ¼ — 75 deg. 56 m.				E W N S — 6 Points ½ — 72 deg. 7 m.				E W N S — 6 Points ¾ — 70 deg. 19 m.				E W N S — 6 Points. — 67 deg. 30 m.				

The 6 Points Quarters.

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile; *which gives the* Difference *of* Lat. *and* Departure *from the* Meridian.

The *Traverse-Table*, The 3 Points Quarter.

Dist. in Leagues or Miles sail'd	25 deg. 19 m.				28 deg. 07 m.				30 deg. 56 m.				33 deg. 45 m.				Dist. in Leagues or Miles sail'd
	2 Points ¼				2 Points ½				2 Points ¾				3 Points.				
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	00	90	00	43	00	88	00	47	00	86	00	51	00	83	00	56	1
2	01	81	00	85	01	76	00	94	01	71	01	03	01	66	01	55	2
3	02	71	01	28	02	65	01	41	02	57	01	54	02	49	01	67	3
4	03	61	01	71	03	53	01	89	03	43	02	06	03	32	02	22	4
5	04	52	02	14	04	41	02	36	04	29	02	57	04	16	02	78	5
6	05	42	02	56	05	29	02	83	05	15	03	08	04	99	03	33	6
7	06	33	02	99	06	17	03	30	06	00	03	60	05	82	03	89	7
8	07	23	03	42	07	05	03	77	06	86	04	11	06	65	04	44	8
9	08	14	03	85	07	94	04	24	07	72	04	63	07	48	05	00	9
10	09	04	04	28	08	82	04	71	08	58	05	14	08	31	05	55	10
11	09	94	04	70	09	70	05	18	09	44	05	66	09	15	06	11	11
12	10	85	05	13	10	58	05	66	10	29	06	17	09	98	06	67	12
13	11	75	05	56	11	46	06	13	11	15	06	68	10	81	07	22	13
14	12	66	05	99	12	35	06	60	12	00	07	20	11	64	07	78	14
15	13	56	06	41	13	23	07	07	12	87	07	71	12	47	08	33	15
16	14	46	06	84	14	11	07	54	13	72	08	23	13	30	08	89	16
17	15	37	07	27	14	99	08	01	14	58	08	74	14	13	09	44	17
18	16	27	07	70	15	87	08	48	15	44	09	25	14	97	10	00	18
19	17	18	08	12	16	76	08	96	16	30	09	77	15	80	10	56	19
20	18	08	08	55	17	64	09	43	17	16	10	28	16	63	11	11	20
21	18	98	08	98	18	52	09	90	18	01	10	80	17	46	11	67	21
22	19	89	09	41	19	40	10	37	18	87	11	31	18	29	12	22	22
23	20	79	09	83	20	28	10	84	19	73	11	82	19	11	12	78	23
24	21	60	10	26	21	17	11	31	20	59	12	34	19	95	13	33	24
25	22	60	10	69	22	05	11	78	21	44	12	85	20	79	13	89	25
26	23	50	11	12	22	93	12	26	22	30	13	57	21	62	14	44	26
27	24	41	11	54	23	81	12	73	23	16	13	88	22	45	15	15	27
28	25	31	11	97	24	69	13	20	24	02	14	39	23	28	15	56	28
29	26	22	12	40	25	58	13	67	24	87	14	91	24	11	16	11	29
30	27	12	12	83	26	46	14	14	25	73	15	42	24	94	16	67	30
31	28	02	13	25	27	34	14	61	26	59	15	94	25	78	17	22	31
32	28	93	13	68	28	22	15	08	27	45	16	45	26	61	17	78	32
33	29	83	14	11	29	10	15	56	28	31	16	97	27	44	18	33	33
34	30	74	14	54	29	98	16	03	29	16	17	48	28	27	18	89	34
35	31	64	14	96	30	87	16	50	30	02	17	99	29	10	19	44	35
36	32	54	15	39	31	75	16	97	30	88	18	51	29	93	20	00	36
37	33	45	15	82	32	63	17	44	31	74	19	02	30	76	20	56	37
38	34	35	16	25	33	57	17	91	32	59	19	54	31	60	21	11	38
39	35	26	16	68	34	40	18	38	33	45	20	05	32	43	21	67	39
40	36	16	17	10	35	28	18	86	34	31	20	56	33	26	22	22	40
41	37	06	17	53	36	16	19	34	35	17	21	08	34	09	22	78	41
42	37	67	17	96	37	04	19	81	36	02	21	59	34	92	23	34	42
43	38	87	18	38	37	92	20	27	36	88	22	11	35	75	23	89	43
44	39	78	18	81	38	80	20	74	37	74	22	62	36	58	24	44	44
45	40	68	19	24	39	69	21	21	38	60	23	14	37	42	25	00	45
46	41	51	19	67	40	57	21	68	39	46	23	65	38	25	25	56	46
47	42	49	20	09	41	41	22	16	40	31	24	16	39	08	26	11	47
48	43	39	20	52	42	43	22	63	41	17	24	68	39	91	26	67	48
49	44	30	20	95	43	21	23	10	42	03	25	19	40	74	27	22	49
50	45	20	21	38	44	10	23	57	42	89	25	71	41	57	27	78	50
51	46	10	21	61	44	98	24	04	43	74	26	22	42	40	28	33	51
52	47	01	22	23	45	86	24	51	44	60	26	73	43	24	28	89	52
53	47	91	22	66	46	74	24	98	45	46	27	25	44	07	29	44	53
54	48	81	23	08	47	62	25	46	46	32	27	76	44	90	30	00	54
55	49	72	23	52	48	51	25	93	47	17	28	28	45	73	30	56	55
56	50	62	23	94	49	39	26	40	48	03	28	79	46	56	31	11	56
57	51	53	24	37	50	27	26	87	48	89	29	30	47	39	31	67	57
58	52	43	24	79	51	15	27	34	49	75	29	82	48	22	32	22	58
59	53	33	25	23	52	03	27	81	50	61	30	33	49	06	32	78	59
60	54	24	25	65	52	91	28	28	51	46	30	84	49	89	33	33	60
70	63	27	29	92	61	73	32	99	60	04	35	98	58	22	38	88	70
80	72	31	34	20	70	55	37	71	68	61	41	12	66	51	44	44	80
90	81	35	38	47	79	37	42	43	77	19	46	26	74	83	50	00	90
100	90	39	42	75	88	19	47	13	85	77	51	41	83	14	55	55	100
200	180	78	85	50	176	38	94	26	171	54	102	82	166	28	111	11	200
	E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S	
	5 Points ¾				5 Points ½				5 Points ¼				5 Points.				
	84 deg. 21 m.				61 deg. 52 m.				59 deg. 4 m.				56 deg. 15 m.				

The 5 Points Quarters.

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile, *which gives the* Difference *of* Lat. *and* Departure *from the* Meridian.

The *Traverse-Table*, The 4 Points Quarter.

Dist. in Leagues or Miles sail'd.	36 deg. 24 m. 3 Points ¼ N	S	E	W	39 deg. 22 m. 3 Points ¼ N	S	E	W	42 deg. 11 m. 3 Points ¼ N	S	E	W	45 deg. 00 m. 4 Points. N	S	E	W	Dist. in Leagues or Miles sail'd.
1	00	80	00	60	00	77	00	63	00	74	00	67	00	71	00	71	1
2	01	61	01	19	01	55	01	27	01	48	01	34	01	41	01	41	2
3	02	41	01	41	02	32	01	90	02	22	02	01	02	12	02	12	3
4	03	21	02	38	03	09	02	54	02	96	02	69	02	83	02	83	4
5	04	02	02	98	03	86	03	17	03	70	03	36	03	54	03	54	5
6	04	82	03	57	04	64	03	81	04	44	04	03	04	24	04	24	6
7	05	62	04	17	05	41	04	44	05	18	04	78	04	95	04	95	7
8	06	43	04	76	06	18	05	07	05	93	05	37	05	66	05	66	8
9	07	23	05	36	06	96	05	71	06	67	06	04	06	36	06	36	9
10	08	03	05	96	07	73	06	34	07	41	06	72	07	07	07	07	10
11	08	83	06	55	08	50	06	98	08	15	07	39	07	78	07	78	11
12	09	64	07	15	09	28	07	61	08	89	08	06	08	49	08	49	12
13	10	44	07	74	10	05	08	25	09	63	08	73	09	19	09	19	13
14	11	24	08	34	10	82	08	88	10	37	09	40	09	90	09	90	14
15	12	05	08	94	11	60	09	52	11	11	10	07	10	61	10	61	15
16	12	85	09	53	12	37	10	15	11	85	10	74	11	31	11	31	16
17	13	66	10	13	13	14	10	78	12	70	11	42	12	02	12	02	17
18	14	46	10	72	13	91	11	42	13	34	12	09	12	73	12	73	18
19	15	26	11	32	14	69	12	04	14	08	12	76	13	44	13	44	19
20	16	06	11	91	15	46	12	69	14	82	13	43	14	14	14	14	20
21	16	87	12	51	16	23	13	32	15	56	14	10	14	85	14	85	21
22	17	67	13	11	17	01	13	96	16	30	14	77	15	56	15	56	22
23	18	47	13	70	17	78	14	59	17	04	15	45	16	26	16	26	23
24	19	28	14	30	18	55	15	22	17	78	16	12	16	97	16	97	24
25	20	08	14	89	19	32	15	86	18	52	16	79	17	68	17	68	25
26	20	88	15	49	20	10	16	49	19	26	17	46	18	38	18	38	26
27	21	69	16	08	20	87	17	13	20	00	18	13	19	09	18	09	27
28	22	49	16	68	21	64	17	76	20	75	18	77	19	80	19	80	28
29	23	29	17	27	22	42	18	40	21	49	19	44	20	51	20	51	29
30	24	10	17	87	23	19	19	03	22	23	20	12	21	21	21	21	30
31	24	90	18	47	23	96	19	67	22	97	20	82	21	92	21	92	31
32	25	70	19	06	24	74	20	30	23	71	21	49	22	63	22	63	32
33	26	51	19	66	25	51	20	93	24	45	22	16	23	33	23	33	33
34	27	31	20	25	26	28	21	57	25	19	22	83	24	04	24	04	34
35	28	11	20	85	27	06	22	20	25	93	23	50	24	75	24	75	35
36	28	91	21	46	27	83	22	84	26	67	24	17	25	46	25	46	36
37	29	72	22	04	28	60	23	47	27	41	24	85	26	16	26	16	37
38	30	52	22	64	29	37	24	11	28	16	25	52	26	87	26	87	38
39	31	33	23	23	30	15	24	74	28	90	26	19	27	56	27	56	39
40	32	13	23	83	30	92	25	38	29	64	26	86	28	28	28	28	40
41	32	93	24	42	31	69	26	01	30	38	27	53	28	99	28	99	41
42	33	73	25	02	32	47	26	64	31	12	28	21	29	10	29	10	42
43	34	54	25	61	33	24	27	28	31	86	28	88	30	41	30	41	43
44	35	34	26	21	34	01	27	91	32	60	29	55	31	11	31	11	44
45	36	14	26	81	34	78	28	55	33	34	30	22	31	82	31	82	45
46	36	94	27	40	35	56	29	18	34	08	30	89	32	53	32	53	46
47	37	75	28	00	36	33	29	82	34	82	31	56	33	23	33	23	47
48	38	55	28	59	37	10	30	45	35	56	32	23	33	94	33	94	48
49	39	36	29	19	37	88	31	08	36	31	32	91	34	65	34	65	49
50	40	17	29	78	38	65	31	72	37	05	33	58	35	35	35	35	50
51	40	96	30	38	39	42	32	35	37	79	34	25	36	06	36	06	51
52	41	77	30	98	40	20	32	99	38	53	34	92	36	77	36	77	52
53	42	57	31	57	40	97	33	62	39	27	35	59	37	48	37	48	53
54	43	37	32	17	41	74	34	26	40	01	36	26	38	14	38	14	54
55	44	18	32	76	42	52	34	86	40	75	36	94	38	89	38	89	55
56	44	98	33	36	43	29	35	53	41	49	37	61	39	60	39	60	56
57	45	78	33	96	44	06	36	16	42	23	38	28	40	30	40	30	57
58	46	59	34	55	44	83	36	79	43	07	38	95	41	01	41	01	58
59	47	39	35	15	45	61	37	43	43	72	39	62	41	72	41	72	59
60	48	19	35	74	46	38	38	06	44	45	40	29	42	43	42	43	60
70	56	22	41	69	44	11	44	41	51	85	47	00	49	49	49	49	70
80	64	25	47	65	61	84	50	75	59	26	53	72	56	56	56	56	80
90	72	28	53	61	69	57	57	09	66	67	60	44	63	63	63	63	90
100	80	32	59	56	77	30	63	43	74	08	67	15	70	71	70	71	100
200	160	64	119	12	154	60	126	86	148	16	134	30	141	41	141	41	200

E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S	
4 Points ¼				4 Points ¼				4 Points ¼				4 Points.				
52 deg.		36 m.		50 deg.		27 m.		47 deg.		49 m.		45 deg.		00 m.		

The 4 Points Quarters.

As for Example.

	100	9951	980
S. ½ *Weſt.*	70	6966	686
	3	299	29
Leagues.	17 : 3	172:16	16:95

Beforegoing, if you take all the *Numbers* in the *Table*, they will ſtand as here appeareth, where the *Southerly Diſtance* is $172\frac{16}{100}$ *Leagues*, and the *Weſterly* is $16\frac{95}{100}$ *Leagues*.

But I hold it more convenient to omit the laſt *Figure* to the right hand, and ſo take the *Tenths*, as in the ſecond *Example*; and then in all things it will agree with the *Traverſe-Scale*, on which if you extend the *Compaſſes* from 100 to 73, the ſame Diſtance will reach from the firſt ½ *Point* next the *Line* of *Numbers*, to $172\frac{1}{10}$; and from the half *Point* of the *Weſting*, to $16\frac{2}{10}$ *Leagues*, as before.

As alſo, If you extend the *Compaſſes* from $172\frac{1}{10}$ the *Difference* of *Latitude*, or from $72\frac{1}{10}$ to $6\frac{8}{10}$, which ſtands for $16\frac{8}{10}$ on this or the like occaſion, and apply this Diſtance from 4 *Points* on the *Tangent-Line* of the *Scale*, and the other *Point* of the *Compaſſes* will reach to ½ *Point*, which is from the *South Weſterly*, as before.

Now for the Point *and* ½ Points *reckoned at the Bottom, it is thus.*

Admit a *Ship* ſails 57 *Leagues* or *Miles North-Weſt and by Weſt*, or the 5th *Rhomb* from the *Meridian*; I would know how much I am to the *VVeſtward*, and how much to the *Southward*.

Diſtance	3 *Rhomb.*	3	
	N	*S* *E*	*W*
57	474	317	
Sailed	*E*	*W* *N*	*S*
	5 *Rhomb.*	5	

Therefore look in the bottom of the *Table* for the 5th *Rhomb*, and in the *Side* for 57 *Leagues* or *Miles*; and in the *Line* of *Meeting* over the fifth *Rhomb* you have 47. 39 or $47\frac{4}{10}$ for the *Weſting*, and 31.67 or $31\frac{7}{10}$ almoſt for the *Northing*.

Now had you been to find the *Northing* and *Weſting* of the third *Rhomb* from the *Meridian*, as *N. W. b. N.* to 57 *Leagues* diſtance, the *Northing* would be $47\frac{4}{10}$, and the *Weſting* $31\frac{7}{10}$, as you ſee ſignified by the *Letters N. S.* and *E. W.* at the head of the *Table*, and *North N. S.* under *E. W.* at the foot of the *Table*. This is ſo plain, it needs no further *Precept*.

Or by the *Traverſe-Scale*, Extend the *Compaſſes* in the *Line* of *Numbers* from 10 or 100, to 57 *Leagues*; the ſame Diſtance will reach from 3 *Points* in the next *Line*, with 5 *Points* of the *Eaſting* and *Weſting*, to 47. 4 *Leagues* or *Miles*; that Diſtance will reach from 5 *Points* in the *Line* of *N.* and *S.* to 31. 7 *Leagues*, as before.

And the *Compaſſes* extended from $47\frac{4}{10}$, to $31\frac{1}{10}$ on the *Line* of *Numbers*; the ſame Diſtance will reach from 4 *Points* in the *Tangent-Line*, to 5 *Points* from the *Meridian*, or 3 *Points* if the Caſe ſo required, as if it had been *N. W. b. N.* The like do in all ſuch *Queſtions*.

Likewiſe by the *Traverſe-Scale*, Let the *Courſe* be given *N. W. b. W.* and *Departure* $47\frac{4}{10}$, To find the *Diſtance* and *Difference* of *Latitude*.

Extend the *Compaſſes* from 5 *Points* in the *Line* of *E. W.* of the *Scale*, to the *Departure*; the ſame *Diſtance* will reach from 10 or 100 in the *Line* of *Numbers*, to 57 the *Diſtance*; And alſo from 5 *Points* in the *Line* of *N. S.* to $31\frac{7}{10}$ the *Difference* of *Latitude*. I make this plain by the *Scale*, by reaſon the *Compaſſes* and the *Scale*, are more portable than the *Book* and *Table*.

A larger *Example* I will give you of the *Tables* and *Traverſe-Scale* together, whereby you may perceive, That the *Artificial Numbers*, *Points*, and *Quarters* agree in all things with the *Table*; nay, I hold the *Scale* the beſt of the two, for the ready allowing for *Variation*, and for *Currents*, which is done by removing the *Compaſſes* from one *Point* or *Diſtance* to another. Now let the *Queſtion* be this,

Suppoſe a *Ship* ſail from the *Iſland* of *Lundy*, in *Latitude* 51 *deg.* 22 *min. North*, and *Longitude* 25 *deg.* 52 *min.* to the *Iſland* of *Barbadoes*, in *Latitude* 13 *deg.* 10 *min. North*, and *Longitude* 332 *deg.* 57 *min.* By the *Plain-Chart*, *Difference* of *Latitude* is 764 *Leagues*, and *Longitude* 1059 *Leagues*, and I ſail theſe ſeveral *Courſes*, (*viz.*) *S. S. W.* $\frac{1}{2}$ *W.* from A to B 400 *Leagues*, *S. W. b. S.* $\frac{1}{2}$ *W.* 125 *Leagues*, and *S. W.* 180 *Leagues*, and *S.W. b. W.* $\frac{1}{2}$ *Weſterly* 190 *Leagues*, *W. S. W.* 146 *Leagues*, and *W. b. S.* 159 *Leagues*, and *South* 8 *Leagues* 7 $\frac{7}{10}$: All theſe *Courſes* and *Diſtances* I ſet down as followeth. In the firſt *Column* is expreſſed the *Days* of the *Month*, and *Diſtance* ſailing upon each *Courſe*; The ſecond, the *Day* of the *Week*; The third, the *Courſe* ſailed; The fourth, the *Diſtance* from the *Meridian*; The fifth, the *Place* and *Point* of each *Courſe* by *Letters*; The ſixth, the *Diſtance* ſailed; The ſeventh, eighth, ninth, and tenth, the *Northing*, *Southing*, *Eaſting*, and *Weſting*, which is the *Difference* of *Latitude* and *Departure* from the *Meridian* in *Leagues* $\frac{7}{10}$ *Parts*; The eleventh *Column* is the *Latitude*; The twelfth, the *Longitude*; The thirteenth, the *Variation* of the *Compaſs*.

	Da. Month.	Da. Week.	Courſe ſailed.	Diſtance from the Meridian.	The Places.	Diſt. ſailed.	North-ing.	South-ing.	Eaſt-ing.	Weſt-ing.	Latitud. Dgr.	Latitud. Min.	Longit. Degr.	Longit. Min.	Variation.
Apr.	21	f	S. W. $\frac{1}{2}$ W.	S.W. 54 *d.* 12 *m.*	From A to K.	1306 Leagu.	764 *Leagues*	704 *Leagu.*	1058 *Leag.*	1058 *Leag.*	51 13	22 10	25 332	52 57	*Eaſterly* 5 *m.*
May	2	c	S. S. W. $\frac{1}{2}$ W.	S. W. 2 *Po.* $\frac{1}{2}$	From A to B.	200 200	*Current ſets* E. S. E.	176 $\frac{4}{10}$ 176 4		94 $\frac{3}{10}$ 94 3	33	44	16	26	*Cur. ſets by eſtim.* E. S. E.
	6	G	S. W. b. S. $\frac{1}{2}$ W.	S. W. 3 *Po.* $\frac{1}{2}$	From B to C.	100 20 5		773 155 39		634 127 32	28	28	12	28	*Variat.* 00 *m.*
	10	d	S. W. S.W. $\frac{1}{2}$ W.	S. W. 4 *Points.* S.W. $\frac{3}{4}$	From C to D.	100 80 12		707 566 87		707 566 80	22	06	5	42	*Variat.* 00 *m.*
	15	b	S. W. by W. $\frac{1}{2}$ W.	S. W. 5 *Po.* $\frac{1}{2}$	From D to E.	100 90		471 424		882 794	17	38	35	19	*Weſterly* 2 *degr.*
	19	f	W. S. W.	S. W. 6 *Points.*	From E to F.	100 40 6		383 153 23		924 370 55	15	50	350	24	*Weſterly* 4 *degr.*
	24	d	W. by S.	S. W. 7 *Points.*	From F to G.	100 50 9		195 98 38		981 490 92	13	11	342	46	*Weſterly* 5 *degr.*
			The Courſe made good.	S.W. 48 *d.* 34 *m.*		1212 $\frac{3}{10}$		763 $\frac{3}{10}$		862	13	11	342	46	

2
763 $\frac{3}{10}$ (38 : 11
220

deg.	*min.*
51	22
38	11
13	11

Latitude of Barbadoes.

This done, add up the *South Column*, which *Sum* is 763 $\frac{3}{10}$ *Leagues*; which reduced into *Degrees*, by dividing by 20 and multiplying the odd *Leagues* under 20 by 3, and adding the *Minutes* in the *Tenths*, you will find the *Difference* of *Latitude* in *Degrees* to be 38 *deg.* 11 *min.* which ſubſtracted from 51 *deg.* 22 *min.* there remains 13 *deg.* 11 *min.* the *Latitude* of *Barbadoes*.

Add up the *Sums* of the *Weſt Column*, which is 862 *Leagues*; that converted into *Degrees*, is 43 *deg.* 6 *min.* Subſtract that from the *Longitude* of the *Iſland* of *Lundy*; if you cannot, add to it 360 *deg.* So 25 *deg.* 52 *min.* added to 360 *deg.* makes 385 *deg.* 52 *min.* Then the *Difference* of *Longitude* ſubſtracted from it, 43 *deg.* 6 *m.* there remains 342 *deg.* 46 *min.* the *Longitude* the *Ship* is in.

You muſt note, The *Degrees* are ſuch that 60 *Miles* or *min.* makes a *Degree* of *Longitude* or *Latitude*, or of a *Great Circle*.

Note, The day we ſet ſail, we put down the day of the *Month* and *Week*, the direct *Courſe* to the *Port* we are bound to, and the *Place* marked with two *Letters*, as

in

in this *Table* A for *Lundy* and K for *Barbadoes*; and alſo under *Diſtance*, the number of *Leagues* upon a ſtraight *Courſe*: and under *Northing* and *Southing*, the *Difference* of *Latitude* in *Leagues* and *Tenth Parts*; and under *Latitude*, the *Latitude* of the two Places; and under *Longitude*, the *Longitude* of the two Places, and alſo the *Variation* of the *Compaſs* from whence we ſet our firſt; which you may ſee all plain in the head of the *Table*, in the *Common Angle* of *Meeting* with the 21 of *April*.

And remember, You have the *Latitude* and *Longitude* given you; therefore by it you muſt find the direct *Rhomb* and *Diſtance*, as you have been ſhewed by the ſecond and ſixth *Caſe* of *Plain Triangles*.

Now if you would ſet down this *Reckoning* on the *Plain Chart* ſeverally, you muſt extend your *Compaſſes* from one of the *Parallels* of *Longitude*, to the *Latitude* you are in; as alſo take off ſo many *Leagues* of the *Meridian Line*, as your *Departure* hath been, reckoning 5 *Degrees* for 100 *Leagues*, and every *Degree* for 20 *Leagues*.

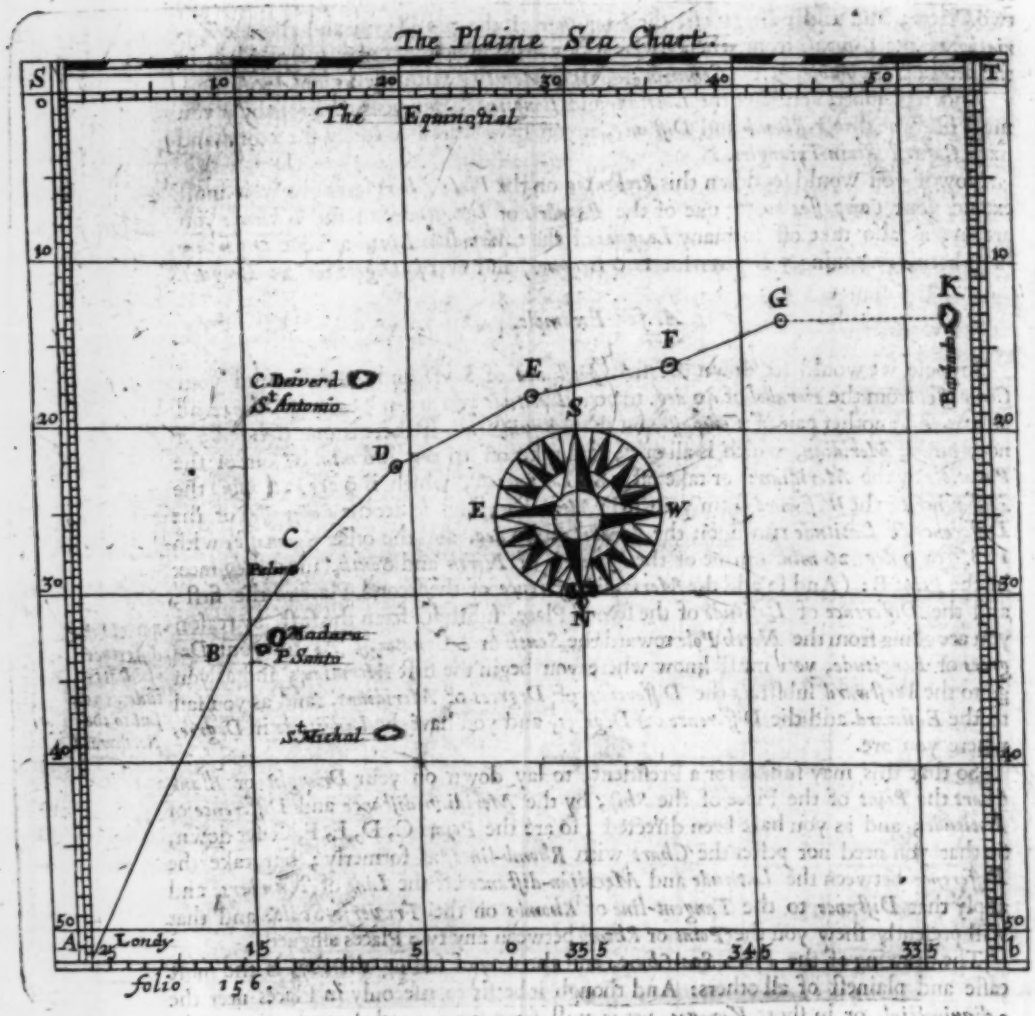
As for Example.

Suppoſe we would ſet down the firſt *Diſtance* of *South* and *Weſt*, Extend your *Compaſſes* from the *Parallel* of 40 *deg.* to your *Latitude* you are in 33 *deg.* 44 *min.* And alſo extend another pair of *Compaſſes* on the *Æquinoctial*, if there is one divided; if not, on the *Meridian*, which is all one; and take off 16 *deg.* 26 *min.* by one of the *Parallels* of the *Meridian*: or take off 188 *Leagues* $\frac{6}{10}$, which is 9 *deg.* 26 *min.* the *Difference* to the *Weſtward* from your firſt *Meridian*; and ſo let the *Compaſſes* of the *Difference* of *Latitude* run upon the *Parallel* of 40 *deg.* and the other *Compaſſes* with 188 $\frac{6}{10}$ or 9 *deg.* 26 *min.* on one of the *Parallels* of *North* and *South*, until they meet in the *Point* B: (And ſo add the *Meridian-difference* of the ſecond Place to the firſt; and the *Difference* of *Latitude* of the ſecond Place, ſubſtract from the firſt, by reaſon you are going from the *North Pole* toward the *South* or *Æquator*.) As for your *Degrees* of *Longitude*, you muſt know where you begin the firſt *Meridian*; and as you go to the *Weſtward* ſubſtract the *Difference* of *Degrees* of *Meridians*, and as you ſail to the *Eaſtward* add the *Difference* of *Degrees*, and you have the *Longitude* in *Degrees* where you are.

But add the difference of Latitude as you ſail to the Northward.

So that this may ſuffice for a Preſident, to lay down on your *Draught* or *Blank Chart* the *Point* of the Place of the *Ship*, by the *Meridian-diſtance* and *Difference* of *Latitude*; and as you have been directed, ſo are the *Points* C, D, E, F, G ſet down, So that you need not peſter the *Chart* with *Rhomb-lines*, as formerly; but take the *Difference* between the *Latitude* and *Meridian-diſtance* off the *Line* of *Numbers*, and apply that *Diſtance* to the *Tangent-line* of *Rhombs* on the *Traverſe-Scale*, and that will preſently ſhew you the *Point* or *Rhomb* between any two Places aſſigned.

The drawing of the *Plain Sea-Chart*, and the way of ſailing thereby, is the moſt eaſie and plaineſt of all others: And though it be fit to uſe only in Places neer the *Æquinoctial*, or in ſhort *Voyages*, yet it will ſerve for a good Introduction to the other kinds of Sailing. Therefore we ſhall not loſe our labour; for in all kinds of Sailing the ſame Work muſt be obſerved with ſome caution.



First make the *Square* A S T B, of what length and breadth you please, and divide each *Side* into as many equal Parts as your occasion requires; and then draw straight *Lines* through these *Parts*, crossing one the other at *Right Angles*, so making many little *Geometrical Squares*, each of which may contain one *Degree*: but I have made this, by reason of its largeness, to contain 10 *Degrees*. Note, That the *Degrees* of the *Meridian* at the *Æquinoctial* are all of equal distance to the *Poles*, which is a gross *Error*, which shall be shewn in the following *Discourse*. So that you may make the *Meridian-Line* in your *Chart* 25 *deg.* 52 *min.* to the *Westward* of the *Meridian* of *Lundy*: Or you may divide the two *Sides* into *Degrees* as far as you think fit, and every *Degree* into 60 *Parts*, which is the old way; and I know most *Mariners* will not be directed a new way of dividing the *Degrees* each of them into 10 *Parts*; so each *Part* will contain about 2 *Leagues*; and that division of double *Leagues* is near enough for the *Mariners* use. You may suppose each of these *Parts* to be subdivided into 10; so every *Degree* will contain 100 *Parts*, which is a very ready way if you keep your *Account* by *Arithmetick*, by *Decimals* or 10 *Parts*. This is so plain, it needs no further *Precept*; therefore we will proceed to the use of it.

Now your several *Courses* and *Traverse-Points* are laid down on your *Chart*, from *Lundy*

Lundy at A, to B the firſt, ſecond to C, third to D, fourth to E, fifth to F, the ſixth to to G, which is the *Point* the *Ship* is in when you caſt up this *Reckoning*. Now to know how far you are ſhort of the *Iſland* by the *Plain Chart*, ſubſtract the *Sum* of the *South Column* 763 $\frac{8}{10}$ from the *Difference* of *Latitude* 764 *Leagues*, and you will find you are but $\frac{2}{10}$ *parts* of a *League* to the *Northward* of your given *Latitude*, which is not to be regarded; and alſo ſubſtract the *Sum* of the *Weſt Column*, from the *Difference* of *Longitude*, and the Remainer is 197 *Leagues*, which you are ſhort at G of the *Barbadoes*; and being in the *Latitude* of 13 *deg.* 11 *min.* the *Iſland* bears off you due *Weſt* at K: So that you ſhould ſail 197 *Leagues* on that *Point Weſt*, before you ſhould be arrived at your *Port* by the *Plain Chart*.

764 00	1058
763 08	862
000 02	196 *Leagues*
	ſhort of Barbadoes *at* G.

But by the true *Sea-Chart* you are arrived at G, which is the *Iſland* of *Barbadoes*: For the true *Meridian-diſtance* is but 865 *Leagues* between *Lundy* and *Barbadoes*, and the *Plain Chart* makes it 1059 *Leagues*; and the true *Courſe* from *Lundy* to *Barbadoes* is but 48 *deg.* 34 *min.* which is *S. W.* a little above a quarter of a *Point Weſterly*, and the *Plain Chart* makes it 54 *deg.* 12 *min. S. W.* which is above $\frac{1}{2}$ of a *Point*; And the true *Diſtance* is but 1152 *Leagues*, and by the *Plain Chart* it is 1366 *Leagues*. By this you may plainly perceive, that no *Iſland*, nor *Cape*, or *Head-Land*, can be truly laid down in the *Plain Chart* in its true ſcituation, but near the *Æquinoctial* only, and near about the ſame may be uſed without ſenſible Error, becauſe there only the *Meridians* and *Parallels* are equal; but on this ſide or beyond the *Æquinoctial*, there is Error committed proportionally to the *Difference* of the *Meridian* and *Parallel*; that is, The true *Difference of Longitude* found out by the *Plain Chart*, hath the ſame proportion to the true *Difference* of *Longitude*, that the *Parallel* hath to the *Meridian*. But moſt *Mariners* will not be drawn from this plain eaſie way of Sailing, notwithſtanding they have it plainly demonſtrated to them by us: But thoſe that take the true way of Sailing, find the Credit and Benefit of it, to the ſhame of thoſe that are ſo obſtinate, conceited, and grounded in Ignorance.

The Errors of the Plain Sea-Chart.

But in the following *Diſcourſe* I will uſe my endeavour to make things ſo plain, that if the Ingenious *Mariner* will but ſpend half an hours time at the ſetting forth of his *Voyage*, to find by direction his true *Courſe* and *Diſtance*, and *Meridian-diſtance*, and put it at the Head of his *Journal*, as you ſee in the *Table*, he ſhall uſe his *Plain Sailing* all the reſt of his *Voyage*; and he ſhall have direction how to uſe it by the *Chart* made according to the *Globe*. But ſomething more of this way, according to my Promiſe.

CHAP. IV.

How to Correct the Account, *when the* Dead Latitude *differs from the* Obſerved Latitude.

WE are come now to make good what was promiſed in the ſecond *Chapter*, to preſcribe four *Precepts* for correcting a *Single Courſe*.

I ſhall be brief, in regard Mr. *Collins*, in *pag.* 22. of his *Mariner's Scale new Plained*, hath imitated *Matius* a *Hollander*, a *Latin Author*, in theſe *Examples*; but good *Rules*, the oftner writ, the more they get.

The Firſt EXAMPLE.

IF a *Ship* ſail under the *Meridian*, if the *Difference* of *Latitude* be leſs by Eſtimation, than it is by Obſervation, the *Ship's Place* muſt be corrected and enlarged under the *Meridian*; and the Error is to be imputed either to the Judgment in eſtimating the *Diſtance* run, in making it too little; or if the ſaid *Diſtance* be eſtimated by a ſound experienced Judgment, it is to be ſuppoſed you ſtem ſome *Current*.

Admit

Admit a *Ship* ſail from A, in the *Latitude* of 36 *deg.* directly *South*, 70 *Leagues*, or 3 *deg.* 30 *min.* and by Eſtimation is at B, but by Obſervation he is in *Latitude* 32 *deg.* The *Reckoning* rectified, the *Ship's* Place is in the *Point* C; but if the *Difference* of *Latitude* be more by Eſtimation, than it is by Obſervation, the Judgment may err, in ſuppoſing the *Diſtance* run to be too much. In this Caſe, the *Diſtance* is to be ſhortned, and the Correction muſt be made according to the *Latitude* obſerved under the *Meridian.*

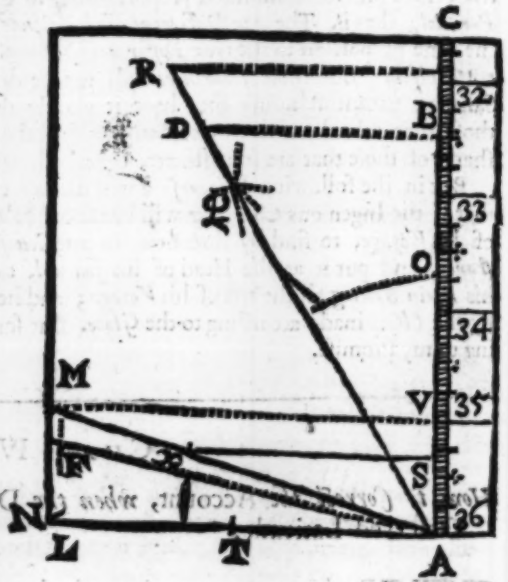
Admit a *Ship* ſail *South* from A, in the *Latitude* 36 *deg.* untill ſhe have altered her *Latitude* 3 *deg.* 30 *min.* by Eſtimation being at B, in *Latitude* 32 *deg.* 30 *min.* and if the obſerved *Latitude* be 33 *deg.* 00 *min.* the *Ship's Place* corrected is at C, and not at B.

Rule II.

SUppoſing no *Current*, If the *Dead Latitude* differ from the *Obſerved Latitude*, the Error is in misjudging the *Diſtance* run, which is to be made longer or ſhorter, as the Caſe requires.

Admit a *Ship* ſail from A, *S. S. E.* ¼ *Eaſterly* 70 *Leagues*, and is by Eſtimation at P in the *Latitude* of 33 *deg.* but if the obſerved *Latitude* be 32 *deg.* 30 *min.* admit at B, then a *Line* drawn through B, parallel to N A, croſſeth the *Line* of the *Ship's Courſe* at Q, which is the Corrected *Point* where the *Ship* is: So that the *Diſtance* is inlarged 10 *Leagues* $\frac{4}{10}$, the whole *Diſtance* A Q is 82 *Leagues* $\frac{4}{10}$.

The ſame manner, If the *Ship* had ſailed 94 *Leagues* on the ſame *Courſe*, and by Eſtimation were at the *Point* R, in the *Parallel* of 32 *deg.* and by Obſervation the *Latitude* were found to be 32 *deg.* 30 *min.* In this Caſe the *Ship's Diſtance* is to be ſhortned, by drawing the foreſaid *Line* B Q parallel to N A; and it will croſs the *Line* of the *Ships Courſe* at Q, the Corrected *Point* where the *Ship* is.



By the Traverſe-Scale.

EXtend the *Compaſſes* from 100, to 94; the ſame *Diſtance* will reach from 2¼ *Points*, to 82 $\frac{4}{10}$ *Leagues* in the *Line* of *Numbers.*

Rule III.

SUppoſe there is ſome *Current*, and you can depend upon the *Obſerved Difference* of *Latitude*, and *Log-diſtance*, as both true; then the Error may be imputed to the *Rhomb*, which alters by reaſon of the ſuppoſed *Current.*

Eſpecially when you ſail in *Rhombs* near the *Eaſt* and *Weſt*; for then if the *Dead Latitude* differ from the *Obſerved Latitude*, the Error is to be imputed either wholly to the *Rhomb*, or partly to the *Rhomb*, partly to the *Diſtance.*

If wholly to the *Rhomb*, then retain the obſerved *Difference* of *Latitude*, and *Diſtance* by Obſervation, and thereby find the *Departure* from the *Meridian*, by drawing a new *Rhomb-line.*

But if your Judgment would allot the Error partly to the *Rhomb*, partly to the *Diſtance*,

Diſtance, keep the obſerved *Difference* of *Latitude*: And for the *Departure* from the *Meridian*, let it be the ſame as was by the *Dead Reckoning*.

Suppoſe a *Ship* ſail *Eaſt by South* ½ a *Point Southerly* 72 *Leagues*, from the *Latitude* of 36 *deg.* from A to M, and by *Dead Reckoning* ſhould be in the *Latitude* of 35 *deg.* If the Obſerved *Latitude* be 35 *deg.* 20 *min.* which is at S; In this Caſe, if the Error be wholly imputed to the *Diſtance*, the *Line* S X being drawn parallel to N A, would cut off or ſhorten the *Diſtance* as much as the *Meaſure* M X, which is 26 *Leagues*; which becauſe it ſeems abſurd and improbable, is not to be admitted of: Wherefore imputing the Error to the *Rhomb* only, place one Foot of the Extent A M in S, and with the other croſs the *Line* N A at L; and ſo is A L the *Departure* from the *Meridian* required; whereby the *Rhomb-line*, if it were drawn, will be ordered to paſs through F the *Croſs*.

By the Traverſe-Scale.

IF you extend the *Compaſſes* from 100, to 72 the *Diſtance*; the ſame Extent will reach from the *Difference* of *Latitude* by Obſervation, to the true *Rhomb*, which is almoſt *Eaſt by South*: and if you apply that *Diſtance* to one *Point* on the *Line N. S.* of the *Scale*, the other will reach to the *Departure* required 70 $\frac{6}{10}$ *Leagues*.— Which is far better than the other way.

The Fourth PRECEPT, CASE, *or* EXAMPLE.

IF a *Ship* ſail *Eaſt* or *Weſt*, and the *Dead* and *Obſerved Latitude* doth agree, the *Reckoning* cannot be corrected; but if they differ, the Error will be partly in the *Rhomb*, and partly in the *Diſtance*: In ſuch a Caſe keep the *Meridian-diſtance*, and the *Difference* of *Latitude* is the *Diſtance* you are gone to the *Northward* or *Southward* of the *Eaſt* and *Weſt*.

By the Traverſe-Scale.

EXtend the *Compaſſes* from 100, to the *Diſtance* ſailed; the ſame Extent will reach from the *Difference* of *Latitude* by Obſervation, to the true *Courſe*: So that you may in a moment do all theſe *Queſtions* and *Caſes* by the *Traverſe-Scale*, and *Line* of *Numbers* and *Artificial Points* and *Quarters* thereon. If you have but the perfect Uſe of it, I know there is no *Inſtrument* whatſoever more ready to reſolve any uſeful *Queſtion*, and correct your *Reckoning*.

Laſtly, If by frequent Obſervation you find the *Ship* is ſtill carried from the *Eaſt* or *Weſt*, either *Northward* or *Southward*, you may conclude ſome *Current* to be the cauſe thereof: Keep the *Diſtance* by *Dead Reckoning* and *Obſervation*, and the *Difference* is the *Diſtance* from the *Parallel*.

We will not multiply too many *Examples*, but rather adviſe the Ingenious to make uſe of ſuch as his need ſhall require; for underſtanding what hath been ſaid, will be advantageous to the *Practitioner*.

CHAP. V.

How to allow for known Currents, *in Eſtimating the* Ship's Courſe *and* Diſtance.

THis Subject hath been largely handled by Mr. *Norwood*, at the end of his *Sea-mans Practice*; and by Mr. *Philips*, in his *Advancement of Navigation*, *page* 54, to 64. As alſo how to find them out by comparing the *Reckoning* homeward with the *Reckoning* outward, which was kept betwixt two Places: Therefore

fore I ſhall be brief, and demonſtrate by *Scale* and *Compaſs*, what they have done by *Tables*.

Firſt, This is eaſie to be underſtood, If you ſail againſt a *Current*, if it be ſwifter than the *Ship's way*, you fall a Stern; but if it be ſlower, you get on head ſo much as is the *Difference* between the *Way* of the *Ship*, and the *Race* of the *Current*.

EXAMPLE.

	mil.
South	8
Current	3
Goes a head	5 S

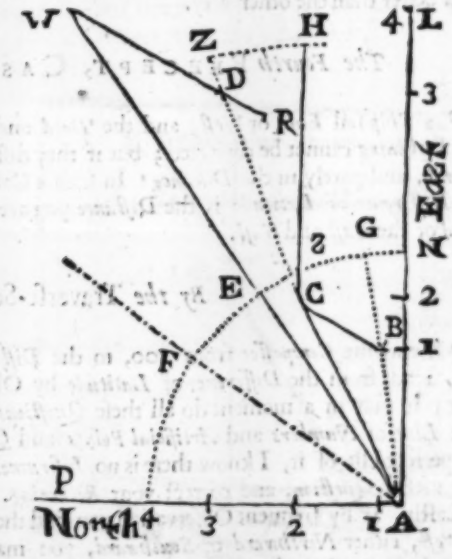
If a *Ship* ſail 8 *Miles South* in an *Hour*, by *Log* or *Eſtimation*, againſt a *Current* that ſets *North* 3 *Miles* in an *Hour*, that ſubſtracted from 8, leaves 5 *Mile* an *Hour* the *Ship* goes a head *South*: But if the *Ship's way* were 3 *Mile* an *Hour South*, againſt a *Current* that ſets 8 *Mile* an *Hour North*, the *Ship* would fall 5 *Miles* an *Hour* a Stern.

	mil.
Current	8
Ships Way	3
Falls a ſtern	5

Admit a *Ship* runs *Eaſt* 4 *Miles* an *Hour*, and the *Current* runs alſo 3 *Miles* an *Hour*, What is the true *Motion* of the *Ship*? *Anſwer*, 7 *Miles* an *Hour* a Head.

Admit a *Ship* croſs a *Current* that ſets *North Eaſt-by-North* 4 *Miles* an *Hour*; the *Ship* ſails in a *Watch*, or 4 *Hours*, 9 *Leagues Eaſt-by North*, and in two *Watches* more ſhe ſails 13 *Leagues E. N. E.* by the *Compaſs*.

Now it is required what *Courſe* and *Diſtance* the *Ship* hath made good from the firſt place of ſetting out from A.



First draw the *Right Line* A L, then with the *Chord* of 60 *Deg.* deſcribe the *Quadrant* on it; to be ſure take 90 *deg.* off the *Line* of *Chords*, and lay it from N to O; then draw the *North Line* A P; then ſet off the *Ship's* firſt *Courſe* one *Point* from the *Eaſt* from N to G, and draw the *Line* A G, and from A to B lay off the firſt *Diſtance* 9 *Leagues*: Then prick off the *Courſe* of the *Current*, being 5 *Points* from N to F, and draw the *Line* A F, being the *Courſe N. E. b. N.* of the *Current*. And becauſe the *Current* in 4 *Hours* ſets 5 $\frac{1}{7}$ *Leagues* forward in its own Race, therefore draw the *Line* B C, parallel to A F, that is, take the neareſt *Diſtance* from B to A F, and ſweep a ſmall *Arch*, and from B to the upper Edge of the *Arch*, draw the *Line* B C thereon, put from B to C 5 $\frac{1}{7}$ the *Currents Motion*, and draw the *Line* A C, which ſhews the *Courſe* the *Ship* hath made good the firſt *Watch*.

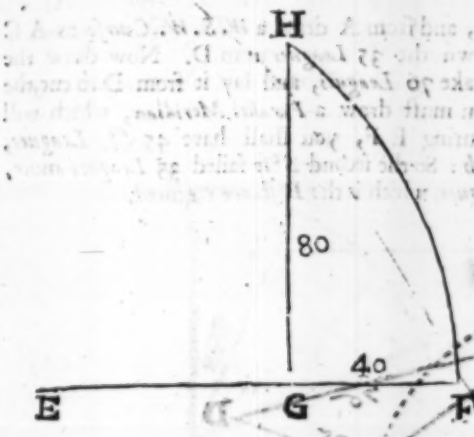
Now for the ſecond *Courſe*, draw C H parallel to the *Line* A L, and with the *Radius* or *Chord* of 60 *deg.* upon C as a *Center*, draw the *Arch* H Z, whereon prick 22 *deg.* 30 *min.* or 2 *Points* for *E. N. E.* for the *Ship's* ſecond *Courſe* from the *Eaſt*; and draw C Z, whereon prick down the *Diſtance* ſailed 13 *Leagues* from C to D; then draw D W parallel to A F, as you did B C; then becauſe the *Current* ſets 10 $\frac{2}{7}$ in two *Watches*, therefore prick down 10 $\frac{2}{7}$ *Leagues* from D to W, and draw the *Line* A W; which being meaſured upon the ſame *Scale* of an *Inch* divided into 10 parts, ſhews the *Ship's* direct *Diſtance* is 35 $\frac{6}{10}$ *Leagues*; whereas if there had been no *Current*, the direct *Diſtance* had been A R 22 $\frac{2}{10}$ *Leagues*: Then meaſure the *Arch* N E, and you will find it 35 *deg.* which is a little above 3 *Points* from the *Eaſt*. So the *Point* the *Ship* hath made good is *North-Eaſt-by-Eaſt* a little *Northerly*; whereas if there had been no *Current*, the *Courſe* had been N S, that is, *Eaſt and by North* $\frac{3}{4}$ of a *Point Northerly*, and had been at R, but now the *Ship* is at W, therefore diſtant from it equal to R W 15 $\frac{6}{10}$ *Leagues*. The prick'd *Lines* are the *Courſes* and *Arches* without a *Current*.

This

This is a good way to work theſe *Queſtions*: If you have no *Compaſſes*, draw on a *Slat* or *Quadrant* to work *Traverſes* by; if you have, that way is the ſooneſt done by them after the ſame manner. Some will expect, that knows me, ſome other ſort of *Queſtions*, (beſides theſe moſt uſeful beforegoing:) For them, and their leiſure-time, I have inſerted theſe ſix *Queſtions* following.

QUESTION I.

A Ship *Sails* 40 Leagues *more than her* Difference *of* Latitude, *and is departed from the* Meridian 80 Leagues, *I demand her* Difference *of* Latitude.



MAke a *Right-Angled Triangle*, ſo that the *Baſe* F G be equal to her *Difference* 40 *Leagues*, and the *Perpendicular* G H equal to her *Departure* 80 *Leagues*: Then continue the *Baſe* F G, and find the *Center point* E unto H and F, ſo it will be E, and G 60 *Leagues* for the *Difference* of *Latitude* ſought.

Arithmetically.

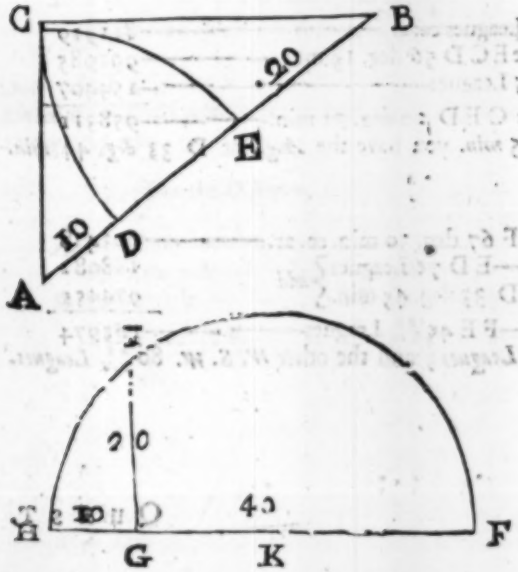
Square G H 80, you have 6400, which divide by G F 40, the *Quotient* is 160; from whence ſubſtract G F 40, there remains 120; the half is 60, for the *Difference* of *Latitude* ſought.

80
80
6400

6400 (160
40
120
60

QUEST. II.

A Ship *Sails* 20 Leagues *more than her* Difference *of* Latitude, *and but* 10 Leagues *more than her* Departure *from the* Meridian, *I demand her* Diſtance *ſailed.*



IN the *Triangle* A B C, you have E B 20 *Leagues* more than the *Difference* of *Latitude* A C; and A D, 10 *Leagues*, more than the *Departure* from the *Meridian* B C.

Firſt, with the double of either *Number*, which here I take, the double of E B 20, wch is 40 *Leagues*, and lay from F unto G; then I take the other *Number* A D 10, and add it thereunto, as G H. Now on the midſt of F H, as at K, making it the *Center*, I deſcribe the *Semicircle* H I F: Then on G erect the *Perpendicular* which cuts the *Arch* in I; then meaſuring

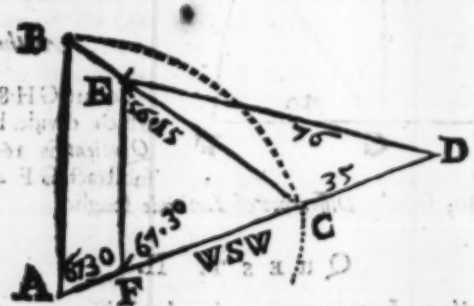
A G I,

20 GI, it will be equal to D E 20 *Leagues*, which added to the two former *Numbers*
10 20 and 10, you have in all 50 *Leagues* for the *Diſtance ſailed*, required.
200
200 *Anabically*: 2 A D : X : E B = D E q 400, whoſe V q is 20, 400 (20 the *Root*.
The Square 400

Quest. III.

Two Ships *Sail from one* Port; *The firſt* Ship *Sails directly* South, *the ſecond* Ship *Sails* W. S. W. *more than the firſt by* 35 Leagues, *and then were aſunder* 76 Leagues; *The* Queſtion *is*, *How many* Leagues *each* Ship *Sailed*.

FIrſt draw the *Meridian-line* A B, and from A draw a *W. S. W. Courſe* as A C continued, and from C lay down the 35 *Leagues* unto D. Now draw the *Chord-line* of 6 *Points*, as B C; then take 76 *Leagues*, and lay it from D to cut the *Chord-line* in E. Laſtly, from E you muſt draw a *Parallel Meridian*, which will cut the *Rhomb-line* in F; ſo meaſuring E F, you ſhall have 45 $\frac{61}{100}$ *Leagues*, that the firſt *Ship* ſailed directly *South*: So the ſecond *Ship* ſailed 35 *Leagues* more, therefore muſt Sail in all 80 $\frac{61}{100}$ *Leagues*, which is the *Diſtance* required.



By the Artificial Tables *of* Sines *and* Numbers.

As the Side E D ——— 76 Leagues co: ar. ——— 811919
To the Sine *of the* Angle E C D 56 deg. 15 min ——— 991985
So is the Side C D ——— 35 Leagues ——— 154407
To the Sine *of the* Angle C E D 22 deg. 31 min. ——— 958311

which ſubſtract from 56 *deg.* 15 *min.* you have the *Angle* at D 33 *deg.* 44 *min.*

Then,

As the Sine *of the* Angle *at* F 67 deg. 30 min. co. ar. ——— 003438
Is to his oppoſite Side ——— E D 76 Leagues } *add* 188081
So the Sine *of the* Angle *at* D 33 deg. 45 min. } 974455
To his oppoſite Side ——— F E 45 $\frac{61}{100}$ Leagues ——— 165974

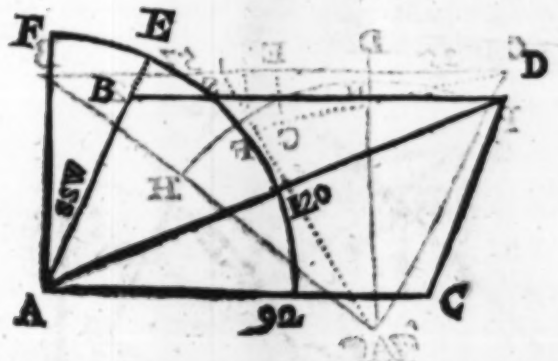
So the *South Ship* Sailed 45 $\frac{61}{100}$ *Leagues*; and the other *W. S. W.* 80 $\frac{61}{100}$ *Leagues*.

Quest.

QUEST. IV.

Two Ships *Sailed from one* Port: *The firſt Sails* S. S. W. *a certain* Diſtance; *then altering her* Courſe, *ſhe Sails due* Weſt 92 Leagues: *The ſecond* Ship *Sailing* 120 Leagues, *meets with the firſt* Ship. *I demand the ſecond* Ship's Courſe *and* Rhomb, *and how many* Leagues *the firſt* Ship *Sailed* S. S. W.

DRaw the firſt *Ship's Rhomb* from A unto E, being *S. S. W.* then lay her *Diſtance* ſailed *Weſt* 92 *Leagues* from A unto C, and from C draw a *S. S. W. Courſe*, as C D continued: Next take 120 *Leagues*, and lay it from A, ſo that it ſhall cut the continued *Line* in D: ſo drawing A D, you ſhall have the ſecond *Ship's Rhomb*, near *W. S. W.* Laſtly, meaſuring C D equal to A B, you ſhall find it to be 49 $\frac{1}{2}$ *Leagues* that the firſt *Ship* ſailed *S. S. W.*



For the *Courſe*,

As the Side A D	120 Leagues, co: ar.	792082
Is to the Sine *of the* Angle *at* B	67 deg. 30 min.	996562
So is the Sine *of the* Side B D	92 Leagues	196379
To the Sine *of the* Angle B A D	45 deg. 6 min.	985023

Unto which add the *Angle* F A B 22 *deg.* 30 *min.* you have the ſecond *Ship's Rhomb* 67 *deg.* 36 *min.* being near *W. S. W.* whoſe *Complement* is the *Angle* A D B 22 *deg.* 24 *min.*

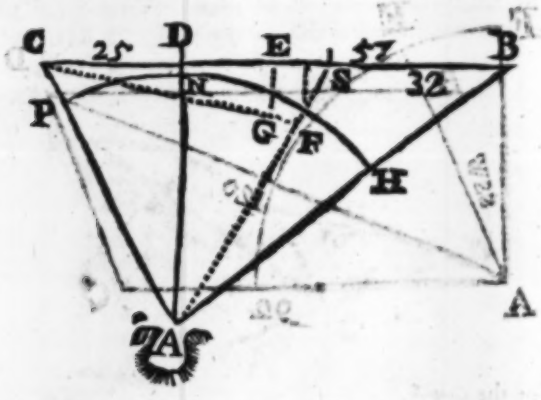
For the *Diſtance*,

As the Angle	B A D 45 deg. 6 min. co. ar.	014976
Is to the Side	B D 92 Leagues	196379
So is the Angle	A B D 22 deg. 24 min.	958101
To the Side A B	49 $\frac{1}{2}$ Leagues *required*	169456

Quest. V.

Two Ships *Sail from one* Port 7 Points *aſunder: The one Sails in the* S. W. Quadrant, *and departs from the* Meridian 57 Leagues; *and the other Sailed in the* S. E. Quadrant, *and was departed from the* Meridian *but* 25 Leagues, *and then are both fallen into one* Latitude; *I demand the* Rhomb *or* Courſes *of each* Ship.

Firſt draw an *Eaſt* and *Weſt Line* continued; and making choice of a *Point* at D, upon D erect a *Perpendicular*, which will be a *Meridian-line*, as D A continued. Now from D lay down the *Weſt Ship's Departure* D B 57 *Leagues*; alſo the *Eaſt Ships Departure* 25 *Leagues* D C: ſo their whole *Diſtance* will be C B 82 *Leagues*. Now upon the *Point* at B, or elſe as here at C, draw an *Angle* of the *Complement* of 7 *Points*, or one *Point*, which is *W. b. N.* as C F the prickt *Line*; but if their *Courſes* had been more than 8 *Points*, then you muſt lay it to the *Southward* of the *Weſt Line*.



Now from the midſt between B and C, at E, draw another *Meridian-line*, until it cut the former *Rhomb-line* C F in the *Point* G: So taking the *Diſtance* from the *Point* G unto C, lay the ſame from G until it cut the *Meridian-line* in the *Point* A, which is the Place and *Port* you Sailed from. Laſtly, From A you ſhall draw their *Rhombs* or *Courſes*, as A B, which is 4 ½ from H to N, from the *South*, *Weſtwards*; and the *Eaſtward Ships Courſe* is A C 2 ½ *Point* from P to N, from the *South*, *Eaſtward*.

1 *Courſe* S. W. ¼ W.
2 *Courſe* S. S. E. ¼ E.

As the Sum *of their* Departures C B 82 Leagues	191381
To the Difference *of their* Departure S B 52 Leagues	150515
So is the Sine *of the* Sum *of their* Courſes C A B 78 deg. 45 min.	999080
To the Sine *of the* Difference *of their* Courſes, Sum	1149595
S A B 22 deg. 30 min. *the* Sum	958214

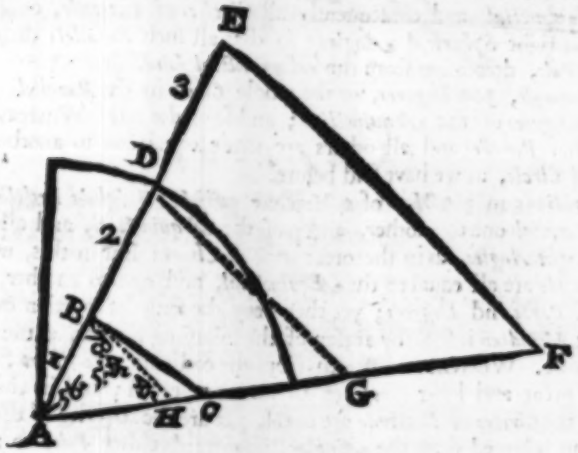
Now 22 *deg.* 30 *min.* added to 78 *deg.* 45 *min.* the half is 50 *deg.* 37 *min.* ½; that is 4 *Points* ½ or *S. W.* ¼ *W.* for the one *Ships Courſe* Sailed from A to B: and 22 *deg.* 30 *min.* ſubſtracted from 78 *deg.* 45 *min.* the half is 28 *deg.* 07 *min.* ½; that is, 2 *Points* and ½ *S. S. E.* ¼ a *Point Eaſterly*, for the other *Ship's Courſe*.

Quest.

QUEST. VI.

From the Port *at* A *I Sail* S. S. W. *unto* B, *and from* B *I Sail* N. W. b. W. *unto* C, *and from* C *I Sailed unto my firſt* Port *at* A, E. b. N. *Now having Sailed in all* 120 Leagues, *I would know how many* Leagues *I have Sailed upon each* Point.

FIrſt draw A B a *S. S. VV. Courſe*, at any convenient diſtance; then from B draw a *N. VV b. VV. Courſe*, and from A draw the oppoſite *Courſe* of *E. b. N.* which is *VV eſt by South*, which will cut B C in C; ſo continue the *Sides* of the *Triangle* A B unto E, and A C unto F. Then lay B C from B unto D, and A C from D unto E. Then take 120 *Leagues*, and lay the ſame from A unto F: Next draw the *Line* E F, and from D and B draw *Parallels* thereunto, which will cut A F in G and H. Laſtly, meaſuring A H, you ſhall have $33\frac{3}{4}$ *Leagues* that you have Sailed *S. S. VV.* And meaſuring H G, you ſhall have 39 *Leagues* $\frac{6}{100}$ *parts* that you have Sailed *N. VV. b. VV.* Alſo meaſuring G F, you ſhall have $46\frac{1}{4}$ *Leagues* near, that you have Sailed *E. b. N.* which makes in all near 120 *Leagues*.



Arithmetically, *By the* Table *of* Natural Sines *in the* Sea-mans Kalendar.

First, Add up all the *Sines* of the *Angles* together,

	deg.	*min.*	
Which is	45	00	7071
	56	15	8314
	78	45	9790
			25175

Then by the *Rule* of *Three*,

As 25194, *to* 120 Leagues: *So* { 45—00, 56—15, 78—45 } *To the* Diſtances *ſailed* { S. S. W. $33\frac{75}{100}$ A B. N. W. b. W. $39\frac{60}{100}$ Leag. E. b. N. $46\frac{25}{100}$ C A.

I might have added ſeveral other *Queſtions* of this nature, but I hold theſe ſufficient; for thoſe that underſtand how theſe are done, may do any of the like nature: But the way of demonſtrating and laying of them down, as you ſee in the *Figures*, I never ſaw before of any other Mans Work. Therefore now we will come to the true way of *Sailing*, and Uſe of the true *Sea-Chart*.

CHAP. VII.

Chap. VII.

The Disagreement betwixt the Ordinary Sea-Chart, *and the* Globe; *And the Agreement betwixt the* Globe *and the* True Sea-Chart, *made after* Mercator's *Way, or Mr.* Edward Wright's *Projection.*

THe *Meridians* in the ordinary *Sea-Chart* are *Right Lines*, all parallel one to another, and consequently do never meet; yet they cut the *Æquinoctial*, and all *Circles* of *Latitude*, or *Parallels* thereunto, at *Right Angles*, as in the *Terrestrial Globe*: But herein it differeth from the *Globe*, for that here all the *Parallels* to the *Æquinoctial* being lesser *Circles*, are made equal to the *Æquinoctial* it self, being a great *Circle*; and consequently, the *Degrees* of those *Parallels*, or lesser *Circles*, are equal to the *Degrees* of the *Æquinoctial*, or any other great *Circle*, which is meerly false, and contrary to the nature of the *Globe*, as shall be plainly demonstrated.

The *Meridians* in the *Terrestrial Globe* do all meet in the *Poles* of the *World*, cutting the *Æquinoctial*, and consequently all *Circles* of *Latitude*, or *Parallels* to the *Æquator*, at right *Spherical Angles*: so that all such *Parallels* do grow lesser toward either *Pole*, decreasing from the *Æquinoctial Line*.

As for Example, 360 *Degrees*, or the whole *Circle* in the *Parallel* of 60 *Degrees*, is but 180 *Degrees* of the *Æquinoctial*; and so of the rest: Whereas in the ordinary *Chart*, that *Parallel* and all others are made equal one to another, and to the *Æquinoctial Circle*, as we have said before.

The *Meridians* in a *Map* of *Mercator* or *Mr. Wright's Projection*, are *Right Lines*, all *Parallel* one to another, and cross the *Æquinoctial*, and all *Circles* of *Latitude*, at *Right Angles*, as in the ordinary *Sea-Chart*: But in this, though the *Circles* of *Latitude* are all equal to the *Æquinoctial*, and one to another, both wholly, and in their *Parts* and *Degrees*; yet they keep the same proportion one to the other, and to the *Meridian* it self, by reason of the inlarging thereof, as the same *Parallels* in the *Globe* do. Wherein it differeth from the ordinary *Sea-Chart*, for in that the *Degrees* of great and lesser *Circles* of *Latitude* are equal; and in this, though the *Degrees* of the *Circles* of *Latitude* are equal, yet are the *Degrees* of the *Meridian* unequal, being inlarged from the *Æquinoctial* towards either *Pole*, to retain the same proportion as they do in the *Globe* it self; for as two *Degrees* of the *Parallel* of 60 *Degrees*, is but one *Degree* of the *Æquinoctial*, or any *Great Circle* upon the *Globe*, so here two *Degrees* of the *Æquinoctial*, or of any *Circle* of *Latitude*, is but equal to one *Degree* of the *Meridian*, betwixt the *Parallel* of 59 $\frac{1}{2}$ and 60 $\frac{1}{2}$; and so forth of the rest.

Now for the making of this *Table* of *Latitudes*, or *Meridional Parts*, it is by an addition of *Secants*; for the *Parallels* of *Latitude* are less than the *Æquator* or *Meridian*, in such proportion as the *Radius* is to the *Secant* of the *Parallel*.

Radius 10000, *to Secant* 20000.

For Example. The *Parallel* of 60 *Degrees* is less than the *Æquator*; and consequently, each *Degree* of this *Parallel* of 60 *Degrees* is less than a *Degree* of the *Æquator* or *Meridian*, in such proportion as 100000 *Radius*, hath to 200000 the *Secant* of 60 *Degrees*.

Now how Mr. *Gunter* and Mr. *Norwood's Tables* are made, which are true *Meridional Parts*, is by the help of Mr. *Edward Wright's Tables* of *Latitude*. Mr. *Gunter's* is an *Abridgment*, consisting of the *Quotient* of every sixth *Number*, divided by 6, and two *Figures* cut off.

As for Example. In the *Tables* of *Latitude* for 40 *Degrees*, the *Number* is

24[2]5 *deg. parts.*

2[8]2779 (43:712 That divided by 6, the *Quotient* is 43 *deg.* 712 *parts* of the

66666

Æquator, to make 40 *Degrees* of the *Meridian*. And Mr. *Norwood's Tables* of *Meridional parts*, is an *Abridgment* of Mr. *Wright's Table* of *Latitudes*; namely,

every

every ſixth *Number* cutting off four *Figures* to the right hand, as for 40 *Degrees*: as before the *Number* is——————————2622|7559
in regard it wants but a little of 760 cut off, we make the *Meridional parts* 2623, as you will find by his *Table*. So this *Table* ſheweth how many *Parts* every *Degree*, and every *Tenth part* of a *Degree* of *Latitude* in this *Chart*, is from the *Æquinoctial*; namely, of ſuch *Parts*, as a *Degree* of the *Æquator* containeth 60. And this which I here exhibit, and call a *Table* of *Meridional Parts*, is alſo an *Abridgment* of the *Table* of *Latitudes* of Mr. *Wright's*, namely, the firſt *Numbers*, omitting always the three laſt *Figures*.

As for Example: All the *Numbers* are for 40 *deg.* 26. 227. 559; omit the three laſt, and divide the reſt by 3, and in the *Quotient* is 8742, the *Meridional parts* for 40 *Degrees*; and ſo of the reſt: So that this *Table* ſheweth how many *Parts* every *Degree*, and every *Tenth part* of a *League*, and every *Tenth Minute* of *Latitude* in this *Chart*, is from the *Æquinoctial* to the *Poles*; namely, of ſuch *Parts* as a *Degree* of the *Æquinoctial* contains 20 *Leagues*. This is large enough for our Uſes at *Sea*, and as ready, being in *Leagues*, by cutting off the laſt *Figure*, which is a *Tenth*: For I could never ſee any *Draught* or *Plat* made according to Mr. *Wright's* Projection, excepting his own in his Book, that is divided into more *Parts* than 6; for all the *Mercator's* or *Dutch Charts* as I have ſeen, are divided into 6 times 10, which is 60 *Minutes*: But he that deſires a larger *Table*, may make uſe of Mr. *Wright's Tables* of *Latitudes*.

The Uſe of this *Table* ſhall partly appear in the *Problems* following, and may be illuſtrated after this manner.

PROBLEM I.

How to find by the following Tables *what* Meridional Parts *are contained in any* Difference *of* Latitude.

YOu muſt take the *Meridional Parts* anſwering to each *Latitude*, and ſubſtract the leſſer from the greater; ſo the Remainer is the Number of *Meridional parts* contained in the *Difference* of *Latitude* propoſed.

As, Let one Latitude *be* 51 deg. 20 min.——12002 }
And the other Latitude *be* 13 deg. 10 min.—— 2657 } Meridional Parts.
9345

The Meridional Parts *contained in the* Difference *of* Latitude *are* 934 1/10 Leag.

The *Degrees* are over the *Parts*, and the *Minutes* are on each ſide under the *Degrees*; and in the *Common Angle* of *Meeting* or *Line* with the *Minutes*, is the *Meridional Parts* you deſire.

PROBL. II.

The Latitudes *of two* Places *being given, and* Difference *of* Longitude *of both* Places, *To find the* Rhomb *and* Diſtance.

TO the intent the Application may be the more evident, our *Examples* ſhall be of two Places before-expreſſed on the *Plain Chart*.

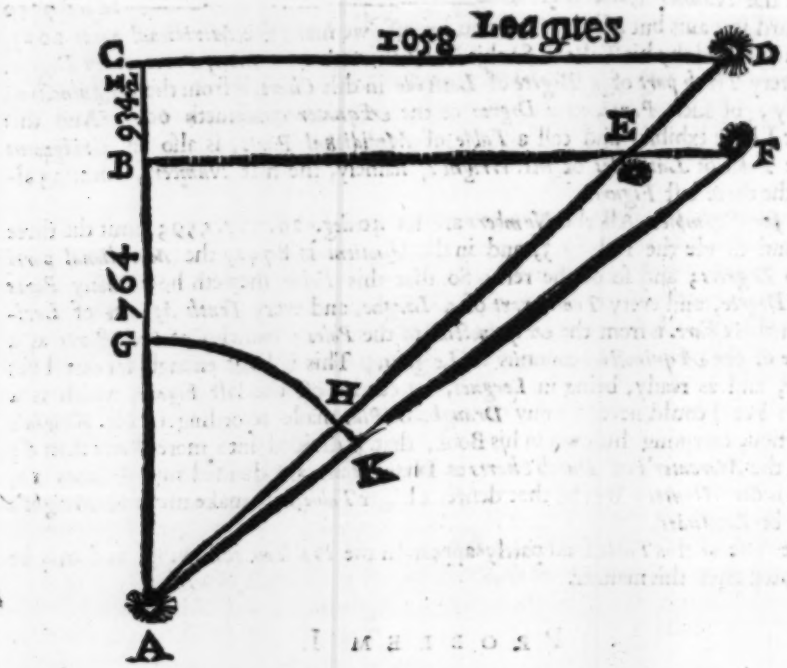
Suppoſe the *Latitude* of the *Iſland* of *Lundy* in the Mouth of *Severn*, to be at A, 51 *deg.* 22 *min.* and the *Latitude* of *Barbadoes* 13 *deg.* 10 *min.* at B, and the *Difference* of *Longitude* 52 *deg.* 55 *min.* C D, that the *Barbadoes* is to the *VV eſtward* of the *Iſland* of *Lundy*; The *Courſe* and *Diſtance* from the one Place to the other is demanded.

Firſt you may demonſtrate the *Queſtion* by the *Scale*. Draw the *Right Line* A C for the *Meridian*; and in regard the *Difference* of *Latitude* is 38 *deg.* 12 *min.* convert them into *Leagues*, by multiplying them by 20, the *Number* that goes to a *Degree*,

	Longitude. d. m.
Lundy	25 52
	360 00
	385 52
Barbad.	332 57
Differ.	52 55

20
1040
18 1/2
1058

51 d. 22 m.
13 10
38. 12 (4
10 3
760
4
764



gree, and the odd *Minutes* divide by 3, and the *Difference* in *Leagues* will be 764; which lay from A to B, for the *Common Difference* of *Latitude*. Then take the *Difference* of the two *Latitudes* inlarged, 934 $\frac{1}{10}$ *Leagues*, and lay from A to C; then draw the two *Parallel Lines*, as B E and C D. Then 52 *deg.* 55 *min.* the *Difference* of *Longitude*, converted into *Leagues*, as before-directed, is 1058 $\frac{1}{2}$, which lay from C to D, and draw the *Line* A D, which is the true *Course* from A to D, and the *Distance* according to the *True Chart* inlarged: Therefore A E is the true *Rhomb-line* and *Distance* found out, produced by the former Work. And as D is the true *Point* by *Mercator's Chart* of *Barbadoes*, so is E the true *Point* of the same Place of *Barbadoes* by the *Plain Chart*; and A E the true *Distance*, B A E the true *Course*. And as C D is the true *Longitude* by the *Globe*, so is B E the true *Meridian-distance* between *Lundy* and *Barbadoes*. You may work afterwards by the *Rules* of the *Plain Chart*; and you need not work *Mercator's* way any more, without you have a *Mercator's True Chart*; and to work by that, you shall be directed in the following *Discourse*. Therefore to work by the *Plain Rules* all the *Voyage* after, measure A E, and you will have 1157 *Leagues* for the *Distance*; and for the *Course* take G H, and apply it to the *Points* on the *Scale*, and you will find the true *Course S. VV.* a little more than a *Quarter VVesterly*, which is all one *Course* with the *True Sea-Chart*; but the *Distance* inlarged is 1408 *Leagues* A D. Now by the *Plain Sea-Chart* the *Course* is B A F, *S. W.* above $\frac{1}{4}$ of a *Point VVesterly*; and the *Distance* is A F 1306 *Leagues*: So that the *Plain Chart* sheweth the *Distance* more than it is by 149 *Leagues*, and the *Course* more *VVesterly* by half a *Point*, and the *Meridian-distance* too much by 194 *Leagues*, which is a gross Error; and in such *Distances* grosly are these Men mistaken, that use a *Plain Chart*.

As was shewed in the last Example.

Then you must put down the Course and Distance and Meridian distance in the Head of your Journal.

A Table

A Table of Meridional Parts *to the* 10 part *of a* League, *and for every* 10 Minutes *of* Latitude *from the* Æquinoctial *to the* Poles.

DEGREES.

Minutes.	0	1	2	3	4	5	6	7	8	9	Minutes.
	Le.	Le.	Le.	Le.	Le.	Le.	Le.	Le.	Le.	Le.	
0	00	200	400	600	801	1001	1202	1403	1605	1807	0
10	33	233	433	634	834	1035	1236	1437	1639	1841	10
20	67	267	467	667	867	1068	1269	1471	1673	1875	20
30	100	300	500	700	901	1102	1303	1504	1706	1909	30
40	133	333	534	734	934	1135	1336	1538	1740	1943	40
50	167	367	567	767	968	1109	1370	1571	1774	1976	50
M.	10	11	12	13	14	15	16	17	18	19	M.
0	2010	2214	2418	2623	2828	3035	3242	3451	3661	3827	0
10	2044	2248	2452	2657	2863	3069	3277	3486	3696	3907	10
20	2078	2282	2486	2691	2897	3104	3312	3521	3731	3942	20
30	2112	2316	2520	2725	2931	3138	3347	3556	3766	3977	30
40	2164	2350	2554	2760	2966	3173	3381	3591	3801	4013	40
50	2180	2384	2588	2794	3000	3208	3416	3626	3836	4048	50
M.	20	21	22	23	24	25	26	27	28	29	M.
0	4084	4297	4512	4729	4947	5167	5388	5612	5837	6065	0
10	4119	4333	4548	4765	4983	5203	5425	5648	5875	6103	10
20	4155	4369	4584	4801	5020	5240	5462	5686	5913	6141	20
30	4196	4405	4620	4838	5056	5277	5500	5724	5951	6179	30
40	4226	4440	4656	4874	5093	5314	5537	5761	5989	6218	40
50	4262	4476	4692	4910	5130	5351	5574	5799	6027	6256	50
M.	30	31	32	33	34	35	36	37	38	39	M.
0	6294	6527	6761	6998	7238	7481	7726	7975	8277	8483	0
10	6333	6565	6800	7038	7278	7521	7768	8017	8270	8526	10
20	6371	6604	6840	7078	7319	7562	7809	8059	8312	8569	20
30	6410	6644	6879	7118	7359	7603	7850	8101	8355	8612	30
40	6449	6683	6919	7158	7400	7644	7892	8143	8397	8655	40
50	6488	6722	6938	7198	7440	7685	7934	8185	8440	8699	50
M.	40	41	42	43	44	45	46	47	48	49	M.
0	8742	9005	9272	9543	9819	10100	10385	10675	10971	11273	0
10	8786	9049	9317	9589	9865	10147	10433	10724	11021	11324	10
20	8829	9093	9362	9635	9912	10194	10481	10773	11071	11375	20
30	8873	9138	9407	9681	9959	10241	10530	10823	11121	11426	30
40	8917	9182	9452	9727	10005	10289	10578	10872	11172	11478	40
50	8961	9227	9498	9773	10052	10337	10626	10922	11222	11529	50
M.	50	51	52	53	54	55	56	57	58	59	M.
0	11581	11896	12217	12545	12881	13226	13581	13941	14313	14696	0
10	11633	11949	12271	12600	12938	13284	13640	14004	14377	14761	10
20	11685	12002	12325	12656	12995	13342	13700	14063	14440	14826	20
30	11737	12055	12380	12712	13052	13401	13759	14121	14504	14892	30
40	11790	12109	12435	12768	13110	13460	13820	14188	14568	14958	40
50	11842	12162	12490	12825	13168	13520	13881	14251	14622	15024	50
M.	60	61	62	63	64	65	66	67	68	69	M.
0	15091	15497	15917	16350	16798	17263	17745	18246	18769	19315	0
10	15158	15586	15988	16423	16874	17342	17827	18332	18858	19408	10
20	15225	15635	16059	16497	16951	17421	17920	18448	18948	19502	20
30	15293	15705	16131	16572	17028	17501	17993	18505	19035	19597	30
40	15300	15775	16204	16647	17106	17582	18077	18592	19130	19693	40
50	15428	15846	16277	16722	17184	17661	18161	18680	19222	19789	50
M.	70	71	72	73	74	75	76	77	78	79	M.
0	19886	20485	21116	21781	22485	23234	24033	24890	25815	26819	0
10	19984	20588	21224	21896	22607	23368	24172	25039	25976	26995	10
20	20083	20692	21333	22011	22730	23495	24312	25190	26140	27173	20
30	20183	20796	21444	22128	22854	23628	24455	25344	26306	27354	30
40	20283	20901	21555	22246	22979	23762	24598	25499	26474	27530	40
50	20384	21008	21668	22365	23106	23897	24743	25656	26645	27727	50
M.	80	81	82	83	84	85	86	87	88	89	M.
0	27917	29130	30484	32019	33789	35881	38441	41740	46387	54331	0
10	28110	29345	30726	32296	34112	36270	38929	42395	47385	56410	10
20	28307	29564	30974	32579	34445	36673	39439	43090	48477	58977	20
30	28507	29787	31226	32870	34788	37096	39973	43830	49684	62274	30
40	28711	30015	31484	33168	35141	37523	40532	44621	51034	66920	40
50	28919	30247	31748	33474	35505	37973	41120	45970	52564	74863	50

By the Tables.

Admit a *Ship* is at A, in *Latitude* 51 *deg.* 22 *min. North*, as is *Lundy*, and ſails, or is to ſail to E, in *Latitude* 13 *deg.* 10 *min.* according to the *Plain Chart* corrected, which is *Barbadoes*; or by *Mercator's Chart*, *Barbadoes* is in the *Point* D, and the *Difference* of *Longitude* is 1058 *Leagues*, which is 52 *deg.* 55 *min.*. Firſt find the *Difference* of *Latitude* inlarged, as is before-directed in the firſt *Problem*, and found to be 934 $\frac{5}{10}$ *Leagues.*

Now you have given A B the *Difference* of *Latitude* 38 *deg.* 12 *min.* inlarged from B to C, and C D the *Difference* of *Longitude* 52 *deg.* 55 *min.* whereby the *Angles* and *Hypothenuſal* ſhall be found by the Fourth and Fifth *Caſe* of *Plain Triangles.*

But becauſe in this kind of *Projection*, the *Degrees* of *Longitude* and *Latitude* are not equal (except in Places near the *Æquinoctial*) the *Degrees* of *Latitude* at every *Parallel*, exceeding the *Degrees* of *Longitude*, in ſuch proportion as the *Æquinoctial* exceeds that *Parallel*; therefore theſe *Differences* of *Longitude* and *Latitude* muſt be expreſſed by ſome one common meaſure; and for that purpoſe ſerves the foregoing *Table*, which ſheweth how many *Equal Parts* are from the *Æquinoctial*, in every *Degree* of *Latitude*, to the *Poles*; namely, of ſuch *Equal Parts* as a *Degree* of *Longitude* contains 20 *Leagues.*

Wherefore, as before-directed, multiplying 52 *deg.* by 20, and dividing the odd *Minutes*, being 55, by 3, it will be 18 $\frac{1}{3}$ *Leagues*; added to the former *Sum*, makes 1058 $\frac{1}{3}$ *Leagues*, for the *Meridional parts* contained in the *Difference* of *Longitude.* Alſo by the laſt *Problem*, I find the *Meridional parts* contained in the *Difference* of *Latitude* to be 934 $\frac{5}{10}$ *Leagues*: So that A C is 934 $\frac{5}{10}$ *Parts*, and C D 1058 $\frac{1}{3}$ of ſuch *Parts.*

Therefore, By the Second Caſe *of* Plain Triangles.

As the Difference *of* Latitude *inlarged* A C *is* 934 $\frac{5}{10}$ parts ——	297057
Is in proportion to the Radius 90 deg. ——	10
So is the Difference *of* Longitude *in ſuch* Parts C D 1058 $\frac{1}{3}$ ——	1302448
To the Tangent *of the* Rhomb *at* A 48 *deg.* 33 *min.* ——	1005391

Extend the *Compaſſes* from 934 $\frac{5}{10}$ *Leagues* the inlarged *Latitude*, to 1058 $\frac{1}{3}$ *Leagues*; the ſame Diſtance will reach from the *Radius* to the *Tangent* of the *Courſe* 48 *deg.* 33 *min.* which is the *Courſe* from *Lundy* to *Barbadoes*, *S. W.* a little above a quarter of a *Point Weſterly.*

By the Fifth Caſe *of* Plain Triangles.

As the Sine-Complement *of the* Rhomb *at* D 41 deg. 27 min. -	982083
To the Difference *of* Latitude A B 764 Leagues ——	288309
So is the Radius 90 deg. ——	10
To the Diſtance A E 1154 $\frac{3}{10}$ *Leagues* ——	306226

Extend the *Compaſſes* from the *Complement-Sine* of the *Rhomb* 41 *deg.* 27 *min.* to the *Sine* of 90 *deg.* the ſame Extent will reach from the true *Difference* of *Latitude* 764 *Leagues*, to the *Diſtance* A E 1157 *Leagues*, which is required.

PROBL. III.

The Latitude *of two Places, and their* Diſtance *given; To find the true* Courſe *and* Point, *or* Place *you are in, by* Mercator's Chart.

ADmit I ſail from the *Iſland* of *Lundy*, in the *Latitude* 51 *deg.* 22 *min.* in the *Southweſt* Quarter of the *Compaſs*, 1154 $\frac{3}{10}$ *Leagues*; and then find my ſelf in the *Latitude* of 13 *deg.* 10 *min.* I would know what *Point* of the *Compaſs* I have ſailed upon, and my *Difference* of *Longitude* to the *Weſtward*.

The *Difference* of *Latitude* A B is 38 *deg.* 12 *min.* which reduced into *Leagues* is 764 *Leagues*.

As the Diſtance *ſailed* 1154 $\frac{3}{10}$ Leagues A E——————— 306226
Is in proportion to the Radius 90 deg.——————— 10
So is the true Difference *of* Latitude 764 Leagues A B——— 288309
To the Sine-Complement *of the* Rhomb 41 deg. 27 min. *at* D 982083

that is, *S. W.* $\frac{1}{4}$ *W.* or *Southweſt* 3 *deg.* 33 *min. Weſterly*, the *Courſe* that the *Ship* hath ſailed upon.

Extend the *Compaſſes* from 1154 *Leagues* the *Diſtance*, to the *Sine* of 90; the ſame *Diſtance* will reach from the *Difference* of *Latitude* 764 *Leagues*, to 41 *deg.* 27 *min.* the *Co-ſine* of the *Rhomb*: The *Sine* is 48 *deg.* 33 *min.* that is, 4 *Points* and above a Quarter from the *South Weſtward* from the *Meridian*.

Secondly, For the *Difference* of *Longitude*.

Find by the Firſt *Problem* the *Difference* of *Latitude* inlarged, as is there directed, 934 $\frac{5}{10}$ *Leagues*: Then it is,

As the Radius 90 deg.——————— 10
To the Difference *of* Latitude *in* Parts 934 $\frac{5}{10}$ A C—— 297057 *Inlarged.*
So is the Tangent *of the* Rhomb 48 deg. 33 min. A——— 1005395
To the Difference *of* Longitude *in* Parts 1058 Leagues— 302452

Extend the *Compaſſes* from the *Sine* of 90 *deg.* to the *Difference* of *Latitude* inlarged 934 $\frac{5}{10}$ *Leagues*; the ſame Extent will reach from the *Tangent* of the *Courſe* 48 *deg.* 33 *min.* to 1058 *Leagues*: which laid off from C to D, ſhall be the *Point* or *Place* in *Mercator's Chart* where the *Ship* is.

Or, 1058 *Leagues* $\frac{1}{2}$ converted into *Degrees*, by dividing by 20, the *Quotient* is 52 *deg.* 55 *min.* the *Difference* of *Longitude* required.

PROBL. IV.

Sailing 1154 Leagues *upon the* 4 $\frac{1}{4}$ Rhomb *from the* Meridian, *or* 48 deg. 33 min. *from the* South Weſterly, *I demand the* Departure *from the* Meridian.

As the Radius 90 deg.——————— 10
To the Diſtance *ſailed* 1154 Leagues A E——————— 306226
So is the Sine *of the* Rhomb 48 deg. 33 min. *at* A——————— 987479
To the Departure *from the firſt* Meridian 865 Leagues——— 493705

Extend the *Compaſſes* from the *Sine* of 90 *deg.* to 48 *deg.* 33 *min.* the ſame Extent will reach from the *Diſtance* ſailed 1154, to the *Meridian Departure* 865 *Leagues*,

B E is the true *Meridian Diſtance*, which you may ſet in the Head of your *Journal*, to ſubſtract your *Daily Diſtance* from your firſt *Meridian*,

PROBL. V.

Both Latitudes *and the* Meridian Diſtance *of two* Places *being given, To find the* Difference *of* Longitude, *and* Courſe *and* Diſtance *on the* True Sea-Chart.

THis is a moſt uſeful *Problem*, when the *Mariner* hath caſt up his *Traverſe*: Suppoſe a *Ship* ſail upon the *S. W.* Quarter of the *Compaſs*, from *Latitude* 51 *deg.* 22 *min.* unto *Latitude* 13 *deg.* 10 *min.* and the *Departure* from the firſt *Meridian* to the *Weſtward* 865 *Leagues*.

You muſt find firſt the *Difference* of *Latitude* inlarged, as is before-directed in the firſt *Problem* 934 $\frac{5}{10}$.

As the true Difference *of* Latitude A B 764 Leagues ——— 288309
Is to the Meridian-diſtance *or* Departure B E 865 Leagues —— 293701
So is the Difference *of* Latitude *inlarged* A C 934 $\frac{5}{10}$ Leagues —— 297057
To the Difference *of* Longitude *in* Leagues 1058 C D ——— 590758
302449

By the Line *of* Numbers.

EXtend the *Compaſſes* from A B the true *Difference* of *Latitude* 764 *Leagues*, to B E 865 *Leagues Meridian-diſtance*; the ſame Extent will reach from A C. 934 $\frac{5}{10}$ *Leagues* the *Difference* of *Latitude* inlarged, to the *Difference* of *Longitude* 1058 *Leagues*; which laid off upon the *Parallel-Line* from C to D, is the *Point* and *Place* of the *Ship* in Mr. *Wright*'s or *Mercator*'s *Chart*.

As the true Difference *of* Latitude 764 Leagues A B ——— 288209
Is to the Meridian-diſtance 865 Leagues B E ——— 1293701
So is the Radius 90 deg. ——— 10,
To the Tangent *of the* Courſe 48 deg. 33 min. *at* A ——— 1005392

By the Artificial Lines *on the* Scale.

EXtend the *Compaſſes* from A B 764 *Leagues*, to B E 865; the ſame *Diſtance* will reach from 90 *deg.* to the *Tangent* of 48 *deg.* 33 *min.* that is, 4 *Points* and above a Quarter from the *South Weſtward*, that is, *S. W.* $\frac{1}{4}$ *Weſterly*, the *Courſe* the *Ship* hath kept.

As the Sine *of the* Courſe *at* A, 48 deg. 33 min. ——— 987479
Is to the Radius 90 deg. ——— 10
So is the Departure *from the* Meridian 865 Leagues ——— 1293701
To the Diſtance *ſailed* A E 1154 $\frac{2}{10}$ Leagues ——— 306222

By the Scale.

EXtend the *Compaſſes* from the *Sine* of 48 *deg.* 33 *min.* at A, to the *Sine* of 90 *deg.* the ſame Extent will reach from 865 *Leagues* B E, to 1154 *Leagues* A E, the *Diſtance* ſailed.

PROBL. VI.

By the Difference *of* Longitude, *and one* Latitude, *and the* Courſe, *To find the other* Latitude *and* Diſtance *run*.

SUppoſe I ſail from *Lundy*, in *Latitude* 51 *deg.* 22 *min. North Latitude*, *S. W.* 3 *deg.* 33 *min. Weſterly*, until my *Difference* of *Longitude* be 52 *deg.* 55 *min.* that is,

is, from C to D, which is the Place of the *Ship* in *Mercator's Chart*; I demand how much I have laid the *Pole*, and how far I am from *Lundy*?

As the Tangent *of the* Rhomb 48 deg. 33 min. —— 1005395
To the Difference *of* Longitude C D 1058 Leagues —— 302448
So is the Radius —— 10
To the Difference *of* Latitude *in* Leagues 934 $\frac{5}{10}$ A C —— 297053

By the Artificial Lines *on the* Scale.

EXtend the *Compasses* from 48 *deg.* 33 *min.* to 1058 in the *Line* of *Numbers*; the same Extent will reach from 90 *deg.* to 934 $\frac{5}{10}$ *Leagues.*

Or, Extend the *Compasses* from 48 *deg.* 33 *min.* to 90 *deg.* the same *Distance* will reach from 1058 *Leagues*, to A C 934 $\frac{5}{10}$ *Leagues*, as before.

Now the *Meridional parts* answering the *Latitude* of 51 *deg.* 20 *min.* is 12002; from it substract 934 $\frac{5}{10}$ here found, and there remains 2657, which *Number* I look for in the *Table*, and find it under 13 *deg.* and in the *Line* of 10 *min.* which is the *Latitude* of the second Place where the *Ship* is; and the *Difference* of *Latitude* is 38 *deg.* 12 *min.*

12002
9345
2657

The *Distance* may be found as before, in the second and fifth *Problems.*

PROBL. VII.

By the Course *and* Distance, *and one* Latitude, *To find the other* Latitude, *and Difference of* Longitude.

SUppose I sail *S. W.* 3 *deg.* 33 *min. Westerly*, 1157 *Leagues*, and by observation find my self in the *Latitude* of 13 *deg.* 10 *min.* I require the *Latitude* of the Place from whence I came, and the *Difference* of *Longitude* between the two Places.

For the *Difference* of *Latitude*,

As the Radius B 90 deg. —— 1000000
To the Distance *sailed* 1154 Leagues A E —— 306222
So is the Sine-Complement *of the* Course E, 41 deg. 27 min. —— 982083
To the Difference *of* Latitude 764 Leagues —— 288315

Extend the *Compasses* from the *Sine* of 90 *deg.* to 1154 *Leagues*; the same will reach from the *Sine* of 41 *deg.* 27 *min.* to 764 *Leagues*, which converted into *Degrees*, is 38 *deg.* 12 *min.* the *Difference* of *Latitude*; which added to 13 *deg.* 12 *min.* the *Latitude* of the last Place, the *Total* is 51 *deg.* 22 *min.* the *Latitude* of the first Place required.

The *Difference* of *Longitude* is found as before in the third *Problem*, saying,

As the Radius, *To the* Difference *of* Latitude *inlarged* 934 $\frac{5}{10}$:
So is the Tangent *of* 48 d. 33 m. *To the* Difference *of* Longitude *in* Leagues 1058, *which is* 52 deg. 55 min.

Now to convert the *Difference* of *Longitude* found in any *Latitude* into *Leagues*, do it after this *Example.*

Suppose two Places in one *Parallel* of *Latitude*, as in the *Parallel* of 51 *deg.* 22 *min.* whose *Difference* of *Longitude* is 52 *deg.* 55 *min.* I require the *Distance* of those two *Places.*

As the Radius —— 10
Is in proportion to the Compl. Sine *of the* Latitude 51 d. 22 m. — 979573
So is the Difference *of* Longitude 1058 Leagues —— 302448
To the Distance *in that* Latitude 661 Leagues —— 282092

You

You muſt underſtand, That the *Leagues* of *Longitude* in any *Parallel* of *Latitude*, are in proportion to the *Diſtance* in *Leagues*, as the *Æquinoctial* is to that *Parallel*; or, as the *Semidiameter* of the one, is to the *Semidiameter* of the other, as was ſaid in the Seventh *Chapter*.

CHAP. VIII.

How to divide a Particular Sea-Chart, *according to* Mercator *and Mr.* Wright's *Projection.*

55:30
49
13401
11427
49
1975
x
197.5 (9:52
20

IF it be a Particular *Chart* you would make, you muſt firſt conſider the two *Latitudes* you would make the *Chart* for; and out of the foregoing *Table* of *Meridional parts*, take the *Numbers* anſwering to each *Latitude*, and ſubſtract the leſſer out of the greater, and the Remain is the *Numbers* which you muſt take for the extreme *Parallel* of *Latitude*.

As for Example, I would make a Blank *Mercator's Chart* from the *Latitude* of 49 *deg.* 30 *min.* to 55 *deg.* 30 *min.* and for 10 Degrees of *Longitude*. Look in the *Table* of *Meridional Parts*, and for the *Latitude* of 49 *deg.* 30 *min.* you will find the *Number* anſwering thereunto is 11426, and the *Numbers* for the *Latitude* of 55 *deg.* 30 *min.* is 13401; the leaſt ſubſtracted from the greater, the Remainer is 197:5 *Equal Parts* for the length of the *Meridian-Line*. Therefore firſt draw the *Line* A B, D C for the *Meridian-Line*, and croſs it with two *Perpendiculars*, as B C and A D: Then divide one of the *Parallels* of *Latitude* into 10 *Equal parts*, as A D, and ſubdivide each of thoſe *Degrees* into 20 *equal parts* or *Leagues* that makes a *Degree* of *Longitude* and *Latitude* at the *Æquator*; and ſuppoſe each of theſe 20 *Parts* to be divided into 10 *parts* more, ſo will a *Degree* be divided into 200 *parts*: Then take with your *Compaſſes* 1975 *Equal parts* out of the *Line* A D, and lay from A to B, and from D to C, for the extreme *Parallels* of *Latitude*; and through each *Degree* of *Longitude* marked with 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, draw *Meridian-lines* parallel to the firſt *Meridian*: Then out of the *Table* of *Meridional parts* collect the *Numbers* anſwering to every 10 *Minutes* of *Latitude*, as in the firſt *Column* of this *Table* annexed, the ſecond *Column* is the *Number* anſwering the *Minutes* of *Latitude* in the *Table* of *Meridional parts*, which ſubſtracted the leſſer from the greater, the Remain is the *Difference*, as in the third *Column* 51 *deg.* for the *Difference* of the two lowermoſt *Numbers*: Then add the *Numbers* together in the fourth *Column* in this manner; 51 for the firſt 10 *minutes*, and 52 added to it, makes 102 for 50 *Minutes*; and 52 added to 102, makes 154 for the *Number* of *Equal parts* you muſt take out of the *Line* A D for 30 *min.* from A to 50 *Deg.* of *Latitude*, and lay it on both ſides of the *Chart*, and draw the *Parallels* of 50 *Degrees* of *Latitude*; and ſo do of the reſt, as you ſee in this *Table*. And for 51 *Degrees* the *Number* is 470; take 470 and lay it upwards from A to 51 *Degrees* on both ſides, and draw the *Parallels* of 51 *Degrees* of *Latitude*; and ſo do with all the reſt.

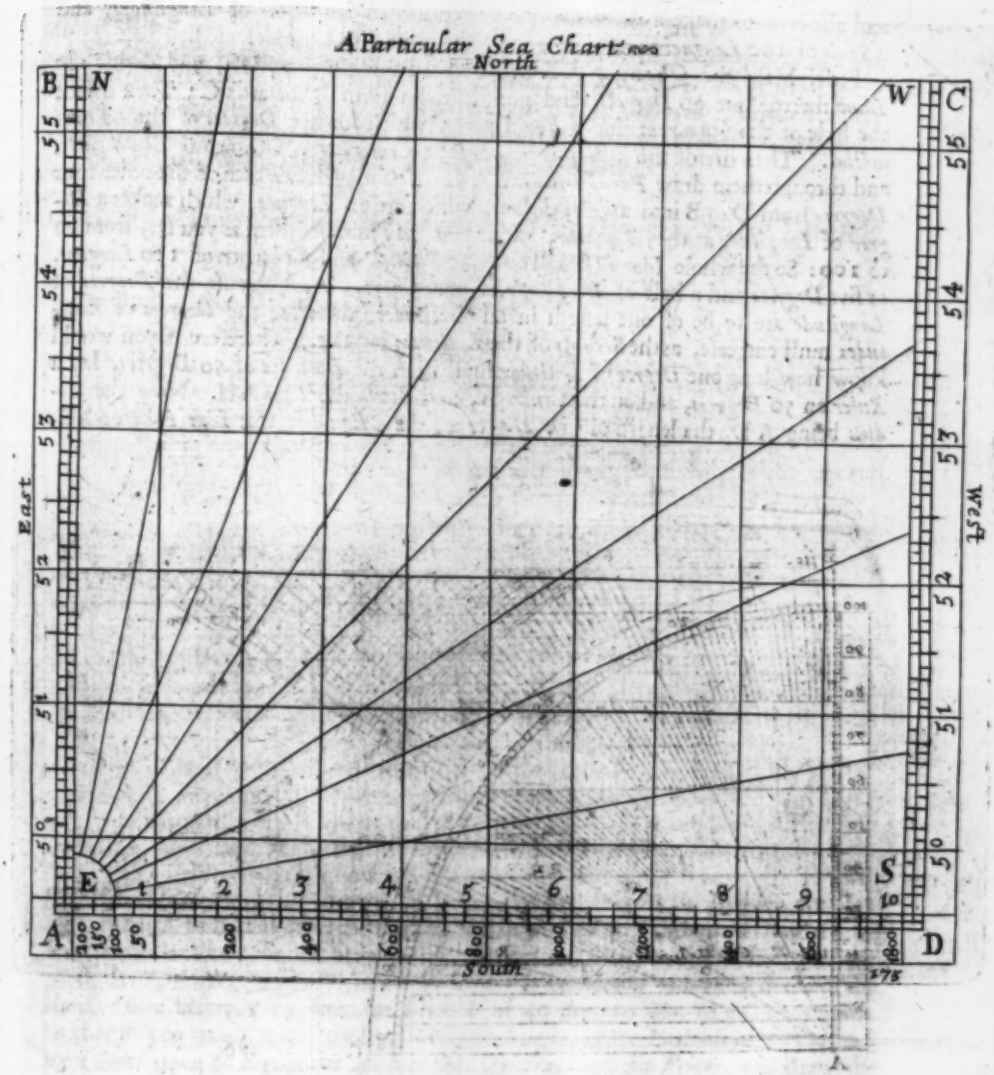
Divide the Difference 197:5 *by* 20, *the* Quotient *will ſhew you the number of* Degrees *of the* Æquinoctial *and* min. *that makes the length of the* Meridian Line; *as for* 6 deg. *from* A *to* D, *will be* 9 d. 55 m. *of the* Æquator.

You may divide every 10 Minutes *into two Equal parts; ſo is every* Degree *divided into* 5 min. *as* A B & D C *into* 10 m.

From D.

Deg.	*Min.*	*Merid. Parts.*	*Differ.*	*Equal Parts.*
	30	13401		1975
	20	13342	59	1921
	10	13284	58	1863
55	00	13226	58	1805
	50	13168	58	1747
	40	13110	58	1689
	30	13052	58	1631
	20	12995	57	1573
	10	12938	57	1516
54	00	12882	57	1459
	50	12825	57	1402
	40	12768	57	1345
	30	12712	56	1288
	20	12656	56	1232
	10	12600	56	1176
53	00	12545	55	1120
	50	12490	55	1065
	40	12435	55	1010
	30	12380	55	955
	20	12325	55	900
	10	12271	54	846
52	00	12217	54	792
	50	12163	54	738
	40	12109	54	684
	30	12055	54	630
	20	12002	53	576
	10	11949	53	523
51	00	11896	53	470
	50	11843	53	417
	40	11790	53	364
	30	11737	53	311
	20	11685	52	258
	10	11633	52	206
50	00	11581	52	154
	50	11539	52	102
	40	11479	52	51
	30	11426	51	

CHAP.



CHAP. IX.

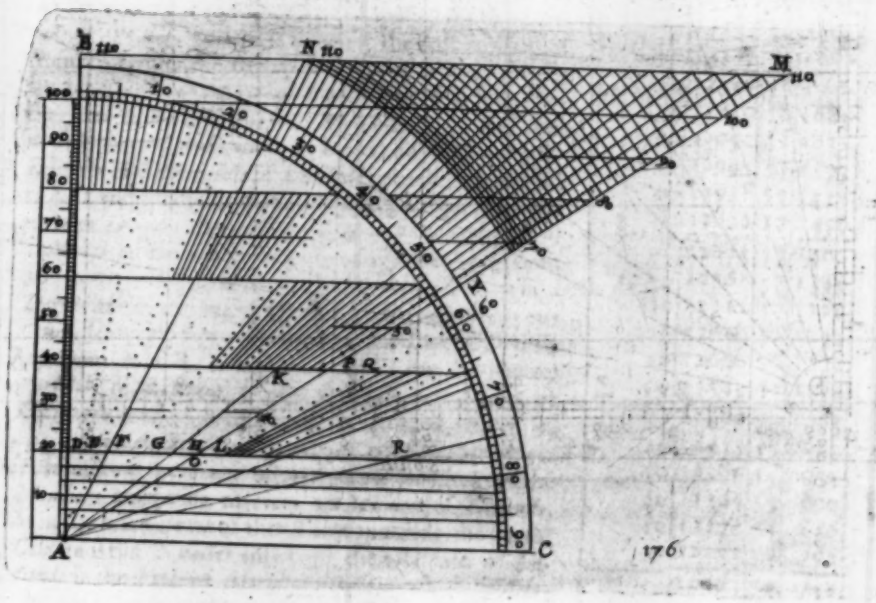
The Projection of the Meridian-Line *by* Geometry, *and how to make a* Scale *of* Leagues *for to measure* Diſtances *in any* Latitude.

THE Projection is the ground-work of Mr. *Wright's Table* of *Latitudes*, in his *Book* called, *The Correction of Errors in Navigation*, where he ſheweth how to make it, and hath alſo made a *Table* by the continual addition of the *Secants* of every *Minute*, which ſhews how much you are to lengthen the *Degrees* of *Latitude* in your *Chart*, that ſo there may be a true proportion between the

Degrees

Degrees of *Longitude* and *Latitude* in all Places. Which *Table* I have abridged, and made it more plain and eaſie, by reducing it into *Leagues* and *Tenth parts*, as hath been ſhewed before. We will here ſhew you how to do the ſame by *Geometry*, and alſo how to make a *Meridian-line* anſwerable to any *Line* of *Longitudes*, and a *Scale* of 100 *Leagues* to meaſure any *Diſtance* in any *Latitude*.

Firſt, Make the *Quadrant* A B C, of what largeneſs you pleaſe, and divide the *Limb* thereof into 90 *Degrees*, and number them from B towards C; Then divide the Side of the *Quadrant* into 5 *Equal parts*, which are five *Degrees* of the *Æquinoctial*. Then divide the firſt *Degree* from the *Center*, as A D, into 6 *Equal parts*, and through them draw *Parallel-lines* to A C: You may divide each of the other four *Degrees* from D to B into 20 *Equal parts*, which are 20 *Leagues*, which makes a *Degree* of *Longitude* at the *Æquator*; and ſo you may number them as you ſee, from 10 to 100: So the whole *Line* A B will be your *Radius*, and the length of 110 *Leagues*, or five *Degrees* and a half of *Longitude* of your *Chart*. And becauſe the *Degrees* of *Longitude* are to be of one length in all *Latitudes*, therefore the *Degrees* of *Latitudes* muſt encreaſe, as the *Secants* of the *Latitudes* increaſe. Therefore if you would know how long one *Degree* of *Latitude* muſt be in the *Latitude* of 50 *Degrees*, lay a *Ruler* on 50 *Degrees*, and on the *Center* A, and draw the *Line* A H. Now the *Radius* being A D, the length of one *Degree* of the *Æquator*, this *Line* A h, or h K,

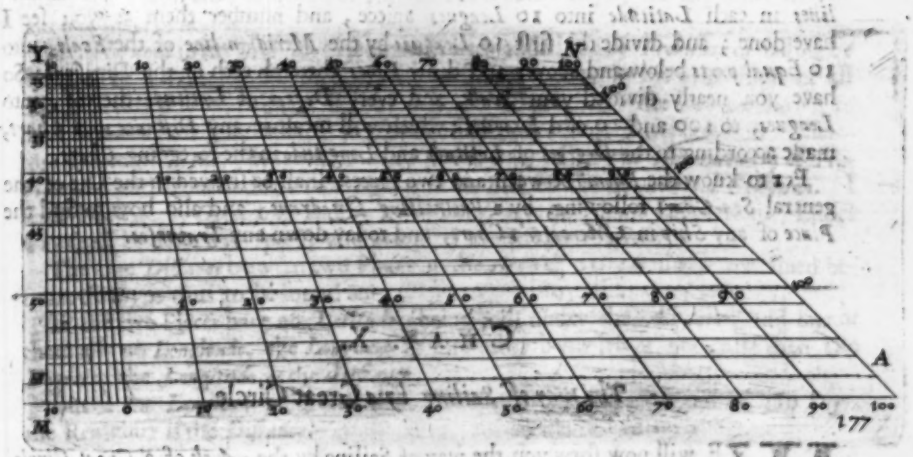


being both of one length, is the *Secant* of 50 *Degrees* to that *Radius*, and muſt be the length of one *Degree* of *Latitude* in a *Chart* from 50 *Degrees* to 51 *Degrees*, as you may preſently try by the former *Chart*; and ſo the *Line* A C which is the *Secant* of 20 *Degrees*, is the length of one *Degree* of the *Meridian-line* in the *Latitude* of 20 *Degrees*; and ſo for any other *Latitude*. The ſix *Lines* divided in the firſt *Degree* A D, are 10 *Minutes* apiece; and ſo you have the *Secant* of every 10 *Minutes* of *Latitude*, and their length in every *Latitude*, for a particular *Chart*, and for a general *Chart*, which hath in it *North* and *South Latitude*.

You may divide the *Quadrant's* Side A B into 10 *Equal parts*, and ſubdivide them into 10 more; ſo will D ♓ be 10 *Degrees* of the *Æquator*, and c ♈ will be the

the length and *Secant* of 10 *Degrees* in the *Latitude* of 20 *Degrees*, and L ♈ the length and *Secant* of 10 *Degrees* in the *Latitude* of 60 *Degrees*, which is twice the length of one *Degree* of the *Æquator*: So that you may presently try the truth of this *Projection*, how it agrees with the *Globe*: Whereas one *Degree* of *Latitude* in the *Globe*, is equal to two *Degrees* of *Longitude* in that *Latitude* of 60 *Degrees*; so here A L the *Secant* of 60 *Degrees*, is twice the length of A D the measure of one *Degree* of *Longitude* in the *Blank Chart*; and L ♈ is twice the length of 10 *Degrees* D ♓: So every *Degree* is two of the *Æquator* in the *Latitude* of 60 *Degrees* of a general *Chart*; and by the *Globe*, in the *Latitude* of 75 *deg.* 30 *min.* one *Degree* of *Latitude* is equal to four *Degrees* of *Longitude*. So in the *Quadrant*, A R is four times the length of A D: and so the Proportion will hold in any other *Latitude*.

A Scale *of* Leagues *from the* Latitude *of* 25 Degrees, *to the* Latitude *of* 57 Degrees 00 Minutes.



How to make the Scale *of* Leagues.

THE *Quadrant* being drawn, as before-directed, take 110 *Leagues* and lay from A to B, and draw the *Line* M N B at *Right Angles* thereunto: and if it be for a particular *Chart*, as that before-going, draw *Lines* from the *Center* through every particular *Latitude*; as you see in the *Quadrant* I have done, to make a *Scale* for the blank *Chart* before-going, from the *Latitude* of 49 *deg.* 30 *min.* to 55 *deg.* 30 *min.* So that if you would know the length of 110 *Leagues* in the *Latitude* of 50 *Degrees*, lay a *Ruler* upon 50 *deg.* in the *Arch* of the *Quadrant* and the *Center*, and draw the *Line* A B, and that is the length of 120 *Leagues* in that *Latitude*. So that if you draw *Parallel-lines* to M N, through every 10 *Leagues* in the Side A B; you will have the length of every 10 *Leagues* in every *Latitude*, as you may plainly see in the *Quadrant*: and so you may do for every *League*, as you see the little *Checkers* betwixt the *Latitude* of 20 *deg.* and 30 *deg.* for 10 *Leagues* between *Latitude* of 50 *deg.* and 56.

Suppose you would know the length of 40 *Leagues* in the *Latitude* of 50 *deg.* Extend the *Compasses* from A to K, and that Distance is 40 *Leagues* in that *Latitude*: And in like manner work by the rest in any other *Latitude*.

If you would make this into a *Scale*, as the *Figure* Y M n N; First in the *Quadrant* extend your *Compasses* from the *Center* A, to the *Intersections* of the *Lines* drawn through every *Degree* M N B, and lay them down upon the Side of the extreme *Latitude* of your *Chart*, as A, O, P, Q, Y, M, with the small *Arches*, as you see I have done from M to N Y, and that is the length of the *Meridian-line* of

your *Scale* or *Degree* of *Latitude* M Y; therefore draw the *Parallel-lines* Y N and M m for the extreme *Parallels* of your *Scale*: Then extend your *Compasses* from Y in the *Quadrant*, to each of the *Intersections* of these small *Arches* that are drawn from the *Intersections* on the *Tangent-line* M N; and from 25 *deg.* uppermost, lay that Extent downward for the *Parallel* of 55 *deg.* of *Latitude*, as the *Line* above the lowermost; and so lay down all your *Latitudes* by these small *Arches*, in like manner; and so neatly divide the Side of your *Scale* M Y of *Deg.* of *Latitude*: Then draw *Parallel-lines* to all these *Degrees*, as you see: Then extend the *Compasses* from the *Center* of the *Quadrant* to M, for the length of the lowermost *Line* of your *Scale* M m for 110 *Leagues*. Then extend the *Compasses* from the *Center* of the *Quadrant* to N, which is the length of 110 *Leagues* in the *Latitude* of 25 *deg.* and it is the *Distance* of the uppermost *Line* Y N of your *Scale*; and draw N m the outside of your *Scale* 110 *Leagues*: So take every 10 *Leagues* from the *Center* A, in the *Line* A M, in *Latitude* 56 *Degrees*, and divide the lowermost *Line* of the *Scale*; and the like do in the *Latitude* of 25, for to divide the uppermost *Line* of the *Scale*; and draw *Lines* through each of them, which will divide all the rest of the *Parallel-lines* in each *Latitude* into 10 *Leagues* apiece, and number them as you see I have done; and divide the first 10 *Leagues* by the *Meridian-line* of the *Scale*, into 10 *Equal parts* below and above; and draw *Lines* through each of the *Divisions*: So have you neatly divided your *Scale*, and every *Degree* of *Latitude* thereof, into *Leagues*, to 100 and 10 odd *Leagues*; which will measure any *Distance* in a *Chart*, made according to the *Degrees* of *Latitude* and *Longitude* in the foregoing *Chart*.

For to know the *Rhomb* between any two Places, shall be shewed in the Use of the general *Sea-Chart* following, by a *Protracting Quadrant*, and also how to find the *Place* of any *Ship* in *Mercator's Chart*, and to lay down any *Traverses*.

Chap. X.

The Way of Sailing by a Great Circle.

WE will now shew you the way of Sailing by the *Arch* of a *Great Circle*, which is the most true way of Sailing of all others, if a Man is sure to have *Winds*, that he may keep neer the *Arch* that goes over any two Places propounded. But there is a great deal of uncertainty in having a constant *Wind* by the *Arch*, so likewise the *Trade-winds* many times lye wide of this *Arch* [illegible] besides many dangers of *Rocks*, and *Sands*, and great *Currents*, and dangerous *Pirates*, which by keeping near the *Arch* may lead Men into many inconveniencies, which may be a greater trouble to a Man, more than by sailing a few *Degrees* the more, for his best advantage and more security; besides the trouble in this way, of keeping of *Accounts*, which Men that watch every 4 *Hours*, cannot allow so much time every *Noon*, nor will be perswaded to do it once in three or four *Days*, in regard *Mercator's Chart* comes neer the very truth. Let the *Wind*, and *Sea*, and *Currents*, or *Pirates*, drive a *Ship* over so far wide of the *Arch*, yet it is all line by that *True Chart*. If you keep a true *Account* of the *Ship's way*, allowing for *Variation* of the *Compass*, and *Getting* of *Currents*, and heaving of the *Sea*, you may at any time have the true *Point* where the *Ship* is, and how to shape a *Course* the most ready and convenient way to the *Port* you are bound to: Yea, I say, these Men that are perfect in this way of sailing, may see by their *Mercator's Chart* the dangers that lie between any two Places, and shun them; and likewise make many *Voyages*, where the *Winds* may favour them, sailing by the *Arch*, and no danger of *Rocks* or *Sands* to trouble them; which will prove a great advantage when your *Course* lies neer *East* and *West*, for sailing upon these two *Points*, Men must altogether upon their *Dead Reckoning* (by the two former ways) but by this way you may help your self, by steering your *Latitude* mainly *Degrees*, by which you may often rectifie your *Account*.

Plain Sailing, Mercator's.

For Example, Admit you were to sail from *Mero* on the *Coast* of *Portugal*, to the

Bay on the back ſide of *Aquamacke* neer *Virginia*, which lye both neer the *Latitude* of 40 *Degrees*; and ſuppoſe the *Difference* of *Longitude* between theſe two Places be 70 *Degrees*: The *Diſtance* of the two Places *Eaſt* and *Weſt* is 53 *deg.* $\frac{1}{4}$ and ſomething more; but the *Diſtance* in the *Arch* of a *Great Circle* is but 52 *deg.* and a little more, that is, 1 *deg.* and about $\frac{1}{4}$ leſs, which is but a little benefit to this, which is the chiefeſt, That in ſailing between two ſuch Places by the *Arch* of a *Great Circle*, you will in the firſt half of the way raiſe the *Pole* 5 *deg.* 41 *min.* and then in the other half depreſs the *Pole* as much; ſo that in the whole *Voyage* you will alter your *Latitude* 11 *deg.* 22 *min.* by ſeveral *Courſes*; by which you may rectifie your *Dead Reckoning*, which you cannot do in ſailing upon a *Parallel* of *Eaſt* and *Weſt*; by which you ſee it is the beſt way of ſailing, as well as the neareſt, eſpecially in ſuch occaſions, if the *Wind* favour you.

This Arch of a Great Circle over two Places in Latitude 40 d. 00 m. *and* Difference of Longitude 70 deg. *is the* Line PW *in the* Diagram *of the* 14. Chap. *of part of the* Globe *in* Plano.

Now concerning this way of ſailing, Mr. *Edward Wright* our Noble Countryman did firſt lay down a way, in his *Book* of *Correction of Errors in Navigation, pag.* 63, 64, and 65, by *Geometry*, which Captain *Santanſtal* did comment upon in his *Book* called the *Navigator*, which was only of a *Parallel Courſe*; for any other way he ſaid but little or nothing.

Mr. *Norwood* in his *Book* of *Trigonometry* hath added many *Problems* of ſailing by the *Arch* of a *Great Circle*; for thoſe that will or can, may by his pains find out all things in this way of ſailing: But as they are difficult, and the way unknown to moſt *Sea-men* how to calculate; ſo they are tedious to thoſe of the beſt skill: Therefore I commend Mr. *Philips* his *Tables*, in his *Book* called *The Advancement of Navigation*, and likewiſe his *Plain Figures* in his *Book* of the *Geometrical Sea-man*. I ſhall likewiſe by *Geometry*, and by *Calculation*, give you ſome ſatisfaction. Either way ſhall be done with ſpeed, and as exactly as need be required.

The true *Diſtance* between two Places in the *Arch* of a *Great Circle* contained betwixt them, is thus to be found out.

If the two Places have no *Latitude* (being both under the *Æquator*, and one of them alſo no *Longitude*, the *Longitude* of the other being leſs or not more than 180 *Degrees*, the *Longitude* is the *Diſtance*.

But if the *Longitude* be greater than 180 *Degrees*, ſubſtract it out of 360 *Degr.* the Remainer is the *Diſtance*.

If two places be in one *Meridian*, and have the ſame *Longitude* both, and but one hath *Latitude North* or *South*, the *Latitude* is the *Diſtance*.

But if both Places agreeing in *Longitude*, have *Latitude* alſo of like denomination (that is, both *Latitudes Northerly*, or both *Southerly*) then ſubſtract the leſſer out of the greater, the Remain is the *Diſtance*.

But if both Places in one *Meridian*, have one *Northerly Latitude*, and the other *Southerly Latitude*, add them together, for the *Sum* is the *Diſtance* in *Degrees*.

	Latitude.
Landſe.	50:15
Ribedev.	43:30
Diſtance	7:45
	20
	140
	15
Leagues	155
Mult. by	3
Miles	465

CHAP. XI.

How to find the true Diſtance *of Places, one of them having no* Latitude: *The other having* Latitude *and* Difference *of* Longitude *leſs than* 180 Degrees, *To find*

1 *Their* Diſtance *in a* Great Circle.
2 *The* Direct Poſition *of the Firſt Place from the Second.*
3 *And the Second Place from the Firſt.*

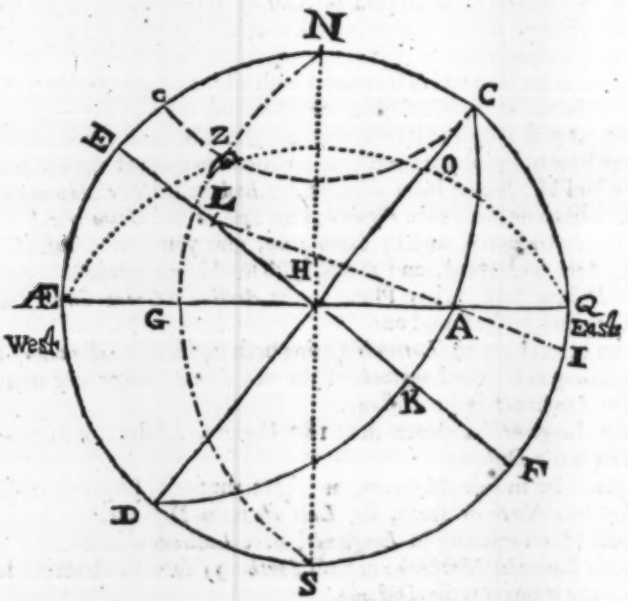
The Firſt Scituation.

FIrſt, If any two Places being propoſed, the one under the *Æquinoctial*, the other may be in any other *Latitude* given, either *North* or *South*, and the *Difference* of *Longitude* of the *Places* being known; you may find the three things before ſpoken of in any *Queſtion*, by the following *Directions*. We call the

Angle that the *Rhomb* leading from one Place to another, makes with the *Meridians*, the *Poſition* of theſe *Places*: But in regard the *Arch* of a *Great Circle*, drawn between two Places, is the moſt neer diſtance from the one Place to the other; therefore the *Angles* which that *Arch* makes with the *Meridian* of thoſe Places, we call the *Angles* of *Direct Poſition*: or direct way of two Places one from the other.

To draw a Great Circle from the Amazones over Lundy, put the Difference of Longitude on the Weſt Side from Æ to G; and draw the prick Line N S, N for the North, and S for the South Pole: and through G draw the Azimuth Circle N G S, and draw the Parrallel of Latitude C Z C; and through Z draw the Arch Æ Z R V Q, for the Circle which paſſeth from Æ Amazones to Z Lundy.

Now in the following *Diagram*, let A be the Entrance of the great *River* of *Amazones*, under the *Æquator*; A Q the *Arch* of the *Æquator*, or *Difference* of *Longitude*; and let C repreſent the *Iſland* of *Lundy*, lying in *Latitude* 51 *deg.* 22 *min. Northerly*, and C Q the *Meridian* thereof: and ſuppoſe the *Difference* of *Longitude* A Q to be 41 *deg.* 22 *min.*



How to do theſe Queſtions Geographically.

FIrſt, With an *Arch* of 60 *Degrees* deſcribe the outward *Meridian* Æ E C Q I F. Secondly, Draw Æ Q the *Æquinoctial Line*. Thirdly, Take 51 *deg.* 22 *min.* of the *Line* of *Chords*, and lay it from Q to C; and draw the *Line* C D through the *Center*, and the *Line* E F at *Right Angles* thereunto. Fourthly, Take off your *Scale* of ½ *Tangents*, counting from 90,—41 *deg.* 22 *min.* and lay from Q to A, for A repreſents the *River* of *Amazones*. Now draw the *Circle* C A D through A, the *Horizon* thereof is E F; then meaſure F K, and apply it to the *Line* of ½ *Tangents*, as before directed: and you will find the *Angle* of *Direct Poſition* to be 48 *deg.* 25 *min.* Take that *Number* out of your *Line* of ½ *Tangents*, from 1 *Degree* forwards towards 90, and lay it from H to L, for the *Pole*, and draw a *Line* from L through A, it will cut the *Line* in I; ſo meaſuring C I on the *Line* of *Chords*, it will be 61 *deg.* 57 *min.* for the *Diſtance*, which is 1237 ½ *Leagues* and 3712 *Miles*.

By the Tables.

THen in this *Triangle* C A Q, *Right-Angled* at Q, there is required C A the neareſt *Diſtance* of the two Places in the *Arch* of a *Great Circle*; and the *Angle* A C Q of *Direct Poſition* from the *Iſland Lundy* to the *Amazones*: and the *Angle*

C Q O

CQO being the *Complement* of the *Angle* of the *Direct Poſition* of the *Iſland* of *Lundy*.

For the neareſt *Diſtance* C A,

As Radius, *is to* Co-ſine *of* Difference *of* Longitude 41 d. 22 m.—987534
So is Co-ſine *of the* Latitude *or* Difference 51 deg. 22 min.——979699
To the Co-ſine *of the* Diſtance 61 deg. 57 min.————967233

which **61** *deg.* 57 *min.* converted into *Leagues*, is 1237$\frac{1}{7}$ as before, the neareſt *Diſtance* between thoſe two *Places*.

For the *Angle* of *Direct Poſition* from the *Amazones* toward *Lundy*, N Æ R,

As the Radius, *to the* Sine *of the* Differ. *of* Longitude 41 d. 22 m.-982011
So is the Co-tangent *of* Difference *of* Latitude 51 deg. 22 min.—990267
To the Co-tangent *of the* Angle *of* Poſition 27 d. 50 m. N Æ R—972278

For the *Angle* of *Poſition* A C Q,

As Radius 90, *is to* Co-ſine *of* Differ. *of* Lat. 51 d. 22 m. Q C— 989273
So is Co-tangent *of* Differ. *of* Longitude 41 deg. 22 m. A Q—1005522
To the Co-tang. *of the* Angle *of* Direct Poſition 48 d. 25 m. A C Q-994795

Meaſure N R *on the half* Tangents, *and the* Angle *of* Poſition, *and the* Diſtance *is all one as before.*

The ſame *Proportions* will hold by the *Artificial Lines* on the *Scale*.

And thus you ſee, he which will ſail the neareſt way from the *Amazones* to the *Lizard*, ſhall at firſt ſhape his *Courſe* 27 *deg.* 50 *min.* from the *Meridian* to the *Eaſtward*; that is, *N. N. E.* almoſt $\frac{1}{4}$ a *Point Eaſterly*. Now if the *Wind* ſhould ſerve that you might ſail this *Courſe*; it is to be underſtood, that in this kind of ſailing he is not to continue this *Courſe* long; but to ſhift it, and incline more and more to the *Eaſtward*, as often as occaſion requires: which how it may be done, ſhall be ſhewed in the following *Diſcourſe*.

PROBL. II.

How to find the Great Circle's *greateſt* Latitude N. *or* S. *or* Obliquity.

NOte, Without the knowledge of the true Quantity of the *Obliquity* or *Latitude* of that *Great Circle* which will paſs directly over the *Places* propounded, there can be no compleat *Demonſtration*, much leſs *Arithmetical Calculation* of things pertaining thereunto; therefore it is needfull that the true Quantity of each *Great Circle's Obliquity* be diligently found to exact certainty: which to do, in ſome Caſes is very eaſie, and in ſome again more difficult. Therefore I will propound *Rules* for the ſeveral *Scituations* following, except thoſe that are ſcituate under the *Æquator*, or under the ſame *Meridian*.

If one Place be under the *Æquator* and hath no *Latitude*, and the other hath any Quantity of *Latitude*, and the *Difference* of *Longitude* being leſs than 90 *deg.* as before 41 *deg.* 22 *min.* it is eaſily found, thus:

The greateſt *Obliquity* in the foregoing *Diagram* is H R V,

As the Sine *of the found* Diſtance 61 deg. 57 min.———— 994573
Is to the Sine *of the* Latitude 51 deg. 22 min.————1989273
So is the Radius (*added to the laſt* Number) } ———— 994700
To the Sine *of the greateſt* Obliquity 62 d. 16 m. }

So 62 *deg.* 16 *min.* is the greateſt *Obliquity* or *Latitude* from the *Æquator*, of that *Great Circle* extended over thoſe two Places.

But

But if the *Difference* of *Longitude* be 90 *deg.* as Æ H, and one of the Places have no *Latitude*, and the other have any Quantity of *Latitude*; then it is evident to reaſon, as in the foregoing *Diagram* may appear, that the ſecond Place is ſcituate in the very *Point* of the greateſt *Obliquity*, which is never above 90 *Degrees*, as H N; and the other Place is in the very *Point* of *Interſection* of the ſaid *Great Circle* with the *Æquator*: For note, That every *Great Circle* that paſſeth over any two Places propounded, cuts the *Æquator* in two oppoſite *Points* 180 *deg.* from each other, as the *Ecliptick Line* doth in the two *Points* of *Aries* and *Libra*; and the greateſt *Obliquity* of that *Circle* is 23 *deg.* 30 *min.* the *Sun's* greateſt *Declination*, and never any more.

Now if one Place have no *Latitude* 00 *deg.* 00 *min.* and the other have any Quantity of *Latitude*, the *Difference* of *Longitude* being more than 90 *deg.* to find the *Obliquity* of the *Great Circle* paſſing over thoſe Places.

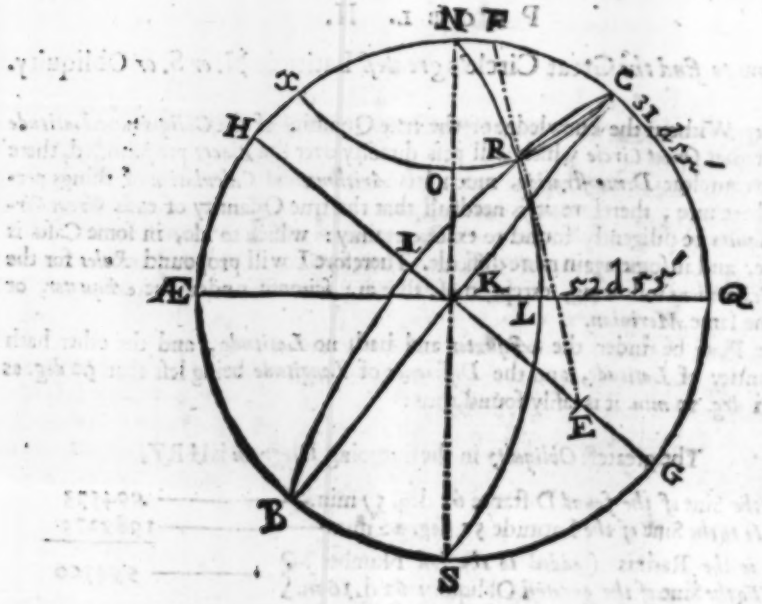
As admit one Place *Latitude* 00 *deg.* 00 *min.* and the other 51 *deg.* 22 *min.* *Difference* of *Longitude* 138 *deg.* 38 *min.* *Diſtance* betwixt them is near 107 *deg.* Therefore take the *Diſtance* 107 *deg.* out of 180, and there remains 73 *deg.* Then,

As the Sine *of the* Remainer 73 deg.	998251
Is to the Sine *of the* Latitude 51 deg. 22 min.	989273
So is Radius	10
To the Sine *of the greateſt* Obliquity 54 deg. 25 min.	991022

So that 54 *deg.* 25 *min.* is the greateſt *Obliquity* of the *Great Circle* extended over theſe two Places. And ſo you may work for any *Queſtions* of this nature.

The ſecond Scituation.

SEcondly, There may be two Places ſcituated in divers *Parallels* of *Latitude*, betwixt the *Artick* and *Antartick Poles*, that may have one *Degree* and *Minute* of *Latitude*, yet may have ſeveral *Degrees* of *Longitude*.



PROBL.

PROBL. III.

Admit there be two Places both in the Latitude *of* 51 deg. 22 min. *and their* Difference *of* Longitude *be* 52 deg. 55 min.

1. *To find the neareſt* Diſtance *of thoſe two Places.*
2. *The* Direct Poſition *of the one Place from the other.*

How to do theſe Queſtions Geographically.

TAke off the *Line* of *Chords* the *Latitude* of the Place 51 *deg.* 22 *min.* and lay from Æ to X, and from Q to C; and take of the ½ *Tangents* the ſame *Latitude*, and lay from K to O; and through theſe three *Points* draw the *Parallel* of *Latitude* XOC; the *Difference* of *Longitude* laid from Q to L, draw the *Meridian-Circle* NLS, the ſecond Place is at R, and firſt at C the *Meridian-circle* cuts at R: Therefore draw the *Circle* from C through R to B, and meaſure H I on the ½ *Tangents*, and you will find it 68 *deg.* 46 *min.* for the *Angle* of *Direct Poſition* HCI. Now from the ½ *Tangents* take 68 *deg.* 46 *min.* and lay it from the *Center* K to E, and from E draw through the *Point* of *Interſection* at R the prickt *Line* E R F; and becauſe it cuts the *Line* in F, therefore meaſure C F on the *Line* of *Chords*, and you will find it 32 *deg.* 18 *min.* for the true *Great Circle Diſtance*, which is 646 *Leagues*, or 1938 *Miles*.

In the Seventh *Problem* of ſailing by *Meridian Chart*, you may ſee there was required the *Diſtance* of theſe two Places meaſured in the *Parallel*, and found to be 660 *l.* 1 but here is required the neareſt *Diſtance* in the *Arch* of a *Great Circle*: Work thus by the *Tables*.

For the *Diſtance*,

As the Radius, *Is to the* Sine-Compl. *of the* Lat. 38 d. 38 m.	R N—979341
So is the Sine of ½ *the* Differ. *of* Longitude 26 d. 27 m.	R F N—984876
To the Sine *of half the* Diſtance 16 deg. 09 min.	R F———944217

Which doubled is 32 *deg.* 18 *min.* and this converted into *Leagues* and *Miles*, as before, is 646 *Leagues*, and 1938 *Miles*, the neareſt *Diſtance*; and leſs than the *Diſtance* meaſured in a *Parallel* by *Miles* 42.

To find the *Direct Poſition*,

As Radius 90, *Is to the* Sine-Compl. *of the* Lat. 58 d. 38 m.	R N—989273
So is the Tangent *of* ½ *the* Differ. *of* Longitude 26 d. 27 m.	R N F—969678
To the Co-tangent *of the* Angle *of* Poſition 68 d. 46 m.	N R F—958951

Which ſheweth, that if you will go the neareſt way from C to R, you muſt not go *Weſt*, though both be under one *Parallel*; but muſt firſt ſhape your *Courſe* from C from *North* 68 *deg.* 46 *min Weſterly*, that is almoſt *W. N. W.* and ſo by little and little inclining to *W. b. N.* and then *W.* and *W. b. S.* and almoſt *W. S. W.* as before.

How to find the Obliquity.

TWo Places having *Latitude* both the ſame, as 51 *deg.* 22 *min.* and towards the ſame *Pole*, whether *North* or *South*, and *Difference* of *Longitude* 52 *deg.* 55 *min.* or any number of *Degrees* under 90: If above 90, take it out of 180, and work with the Remaines the ſame manner of way.

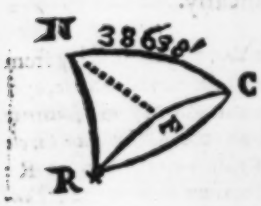
PROBL. IV.

As Radius 90, *To* Co-tangent *of the* Latitudes 51 d. 22 m.	R N—990267
So is the Co-ſine *of* ½ *the* Differ. *of* Longitude 26 d. 27 m.	R N F—995197
To the Compl. Tan. *of the greateſt* Obliquity 54 d. 25 m.	N F—985464

So

So that the greateſt *Obliquity* is 54 *deg.* 25 *min.* And the ſame Proportion will hold for any *Queſtion* of this nature.

We might proceed to frame many *Queſtions* touching thoſe two Places; but theſe being the moſt material, I leave the reſt to your own Practice, to uſe as much brevity as I may. I might have ſhewn you the *Side* and *Angles*; but in regard they are *Spherical* I omit it, and ſhall demonſtrate them at laſt in *Plano*: But you may follow theſe *Rules*, if you cannot apprehend the *Diagram*; but ſome may deſire the *Triangle*, therefore I lay it down.

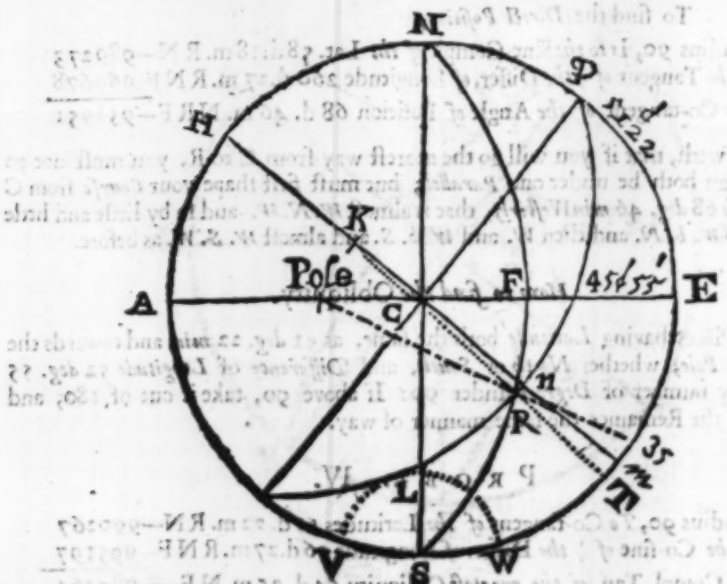


In this *Triangle* C R N, let the two Places be C and R, and let N be the *North Pole*; then C N or R N either of them are 38 *deg.* 38 *min.* the *Complement* of the *Latitude* and the *Angle* C N R is the *Difference* of *Longitude*: There is required C F R the neareſt *Diſtance*, and the *Direct Poſition* of the one to the other, N C R or N R C; for in this Caſe thoſe two *Angles* are equal: And ſeeing N C and N R are equal, therefore let fall the *Perpendicular* N F, the *Triangle* N C R is divided into two *Right-angled Triangles* C N F and R N F, which are every way equal.

The Third Scituation.

One Place having North Latitude, *and the other Place having* South Latitude, *of different Quantities, and the* Difference *of their* Longitudes *leſs than* 90. *As I omit one Place having* North Latitude, *as* Lundy, 51 deg. 22 min. *the other* South Latitude, *as the* Rio de la Plata, 35 deg. 00 min. Difference *of* Longitude *betwixt them* 45 deg. 55 min. *I demand the* Diſtance, *the* Angle *of* Poſition, *and the greateſt* Latitude *or* Obliquity *of the* Great Circle *that paſſeth over theſe two Places.*

AFter you have deſcribed the outward *Meridian* N E S A, take from the *Line* of *Chords* the *Latitude* 51 *deg.* 22 *min.* and lay it from E to P, and draw the *Line* P C O and H C M at *Right Angles* to P, take off the half *Tangent Line* the *Dif-*



ference

ference of *Longitude* 45 *deg.* 55 *min.* and lay it from E to F, and draw the *Meridian-Circle* N F S, whereon lay the *Latitude* of *Rio de la Plata* 35 *deg.* from F to R, by taking 35 out of the *Line* of *Chords*, and laying it from E to 35, and the ½ *Tangent* of F E from C to *Pole*, and draw the prick'd *Line Pole* 35, which cuts the *Circle* N F S in R, the *Rio de la Plata*: and through R draw the *Circle* P R O, and measure M N on the half *Tangents*, you will find the *Angle* of *Position* to be R P E 36 *deg.* 2 *min.* Then take the half *Tangent* of 36 *deg.* 2 *min.* and lay from C to K, and draw the prick'd *Line* from K through R, and it will cut the *Line* at T; therefore measure T P on the *Line* of *Chords*, and that is the measure of R P 95 *deg.* 18 *min.* for the *Diſtance*, or 1906 *Leagues*, or 5718 *Miles*: The greateſt *Latitude* or *Obliquity* is from A E to L; and V L W is the *Parallel* of 68 *deg.* 21 *min.* the greateſt *Obliquity* required,

PROBL. V.

Then by the *Tables*,

As Radius, *To the* Co-ſine *of* Differ. *of* Longitude 45 d. 55 m.—984242
So is the Co-tangent *of the greater* Latitude 51 deg. 22 min.——990267
To the Tangent *of the firſt* Arch 29 deg. 5 min.——974509

The leſs *Latitude* 35 *deg.* and 90 *deg.* makes 125 *deg.* Take the firſt *Arch* 29 *deg.* 5 *min.* therefrom, and there remains 95 *deg.* 55 *min.* Take this out of 180 *deg.* and there remains 84 *deg.* 5 *min.* the ſecond *Arch*: Then

As Co-ſine *of the firſt* Arch 29 deg. 5 min.——994005
Is to the Co-ſine *of the ſecond* Arch 84 deg. 15 min.——901318
So is the Sine *of the greater* Latitude 51 deg. 22 min.——989273

Out of—— 180 00 } *To the* Co-ſine *of* 84 d. 42 m.——890591 *Sum*
Take—— 84 42 }
And there remains 95 18 } *The true* Diſtance 95 d. 18 m.——896586
which was required.

Now to find the *Obliquity*, Take both their *Latitudes* as if they were *North*, or both *South*, and the *Complement* of the *Difference* of *Longitude* to 180 *deg.* which here is 134 *deg.* 05 *min.* half that is 67 *deg.* 2 *min.* 30″: both the *Latitudes* added together make 86 *deg.* 22 *min.* half that is 43 *deg.* 11 *min.* it being too little, I added about 1 *deg.* 20 *min.* to the half, to find the mean and true *Latitude* 44 *deg.* 31 *min.* by which I find the *Obliquity*, as I proved by this *Operation*.

As Radius, *To* Co-tangent *of the* Latitude 44 deg. 31 min.——1000732
So is Co-ſine *of half the* Difference *of* Longitude 67 deg. 2 min.—959158
To the Co-tangent *of the* Obliquity 68 deg. 21 min.——959890

Now to find whether 68 *deg.* 21 *min.* be indeed the true *Obliquity*, make theſe Proofs of it.

As Radius, *To* Co-tangent *of* Obliquity 68 *deg.* 21 *min.*——959890
Take from it the Tangent *of the* Latitude 51 deg. 22 min.——990267
There remains the Co-ſine *of* Differ. *of* Longitude 60 deg. 14 min.—969623

Again,

As Radius, *To* Co-tangent *of* Obliquity 68 deg. 21 min.——1959890
Take out the Co-tangent *of the other* Latitude 35 deg. 00 min.—1015477
There remains Co-ſine *of* Differ. *of* Longitude 73 deg. 51 min.— 944413

	60	14
Now both the *Longitudes* found, 73 *deg.* 51 *min.* and 60 *deg.* 14 *min.* added together,	73	51
	134	05

together, makes juſt 134 *deg.* 05 *min.* the *Difference* of *Longitude* at firſt propounded betwixt thoſe two Places; which proves, That the greateſt *Obliquity* of the *Great Circle* that paſſeth directly over theſe two Places, the *Iſland Lundy* and *Rio de la Plata*, ſo ſcituate, is 68 *deg.* 21 *min.*

Now if it ſo happen that both the *Latitudes* be of the ſame Quantity, as one Place *North Latitude* 11 *deg.* 30 *min.* and the other Place *South Latitude* 11 *deg.* 30 *m.* and the *Difference* of *Longitude* betwixt the two *Longitudes* 55 *deg.* 48 *min.* To find the true *Great Circles Diſtance* betwixt ſuch Places, firſt divide the *Difference* of *Longitude* into two equal parts, and then take one *Latitude* and half the *Difference* of *Longitude*, and find the *Diſtance* belonging to one *Latitude*, which doubled, yields the whole *Diſtance* betwixt the Places propounded: As *Longitude* 55 *deg.* 48 *min.* halfed is 27 *deg.* 54 *min.* and *Latitude* 11 *deg.* 54 *min.* Then work thus.

As Radius, *To* Co-ſine *of* Differ. *of* Longitude 27 d. 54 m. —— 994633
So is the Co-ſine *of the* Latitude 11 deg. 30 min. —— 999119
To the Co-ſine *of* 30 deg. *half the* Diſtance —— 993752

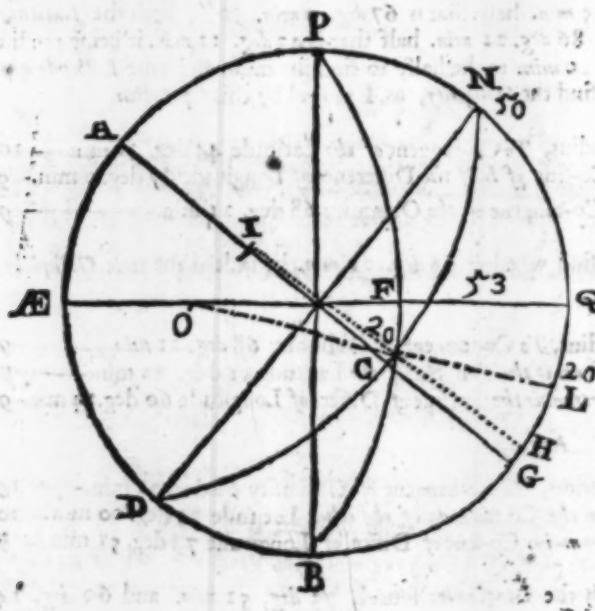
which doubled is 60 *deg.* the whole *Diſtance* betwixt one Place *South* Latitude 11 *deg.* 30 *min.* and and another *North Latitude* 11 *deg.* 30 *min.* having 55 *deg.* 48 *min.* *Difference* of *Longitude*. And ſo work for any two Places ſo ſcituate.

Geographical Queſtions.

Two Ships *being at* Sea, *their* Difference *of* Longitude *was* 53 deg. *Now upon a day they obſerved the* Sun *being between them; the* North Ship *found the* Sun's Meridian Height 33 deg. *and the* South Ship 77 deg. *the middle* Latitude *between them was* 15 deg. North *of the* Æquinoctial Line: *I demand the* Angle *of* Poſition, *and* Diſtance *from the* North Ship *to the* South?

Meridian Altitude.
33d. *Compl.* 57 deg.
77d. *Compl.* 13 deg.
Sum 70
½ *Sum* 35
Mid. Lat. 15
Nor. Ship 50 lat.
South Ship 20 lat.

FIrſt add the two *Meridian Altitudes Complement* together, 33 *deg.* and 77 *deg.* *Complement* 57 and 13, the *Sum* is 70, the half *Sum* is 35 *deg.* the middle *Latitude* 15 add the middle *Latitude* and half *Sum* together, it makes 50 *deg.* the



North

North Ships Latitude; and ſubſtract the middle *Latitude* from the half *Sum*, and the Remain is 20 *deg.* the *Latitude* of the *South Ship*. The *North Ships Latitude* is laid from Q to N 50 *deg.* the *Difference* of *Longitude* Q F 53 *deg.* Through F deſcribe the *Great Circle Meridian* P F B, on which lay down the *South Ships Latitude* 20 *deg.* as F C, and ſo draw the *Great Circle* N C D through the *Interſection* of the prick'd *Line* I H, with the *Meridian* at C; for that is the *Latitude* of the ſecond *Ship*. So the *Angle* of *Poſition* is N C Q, whoſe meaſure is C G on the half *Tangents* 48 *deg.* 58 *min.* from the *South Weſtwards*; and the *Diſtance* is N H 48 *deg.* 22 *min.* that is, 1683 ⅓ *Leagues*, or 5051 *Miles*, the neareſt *Diſtance* of the two *Ships*, which was required. How to do it by the *Tables*, you have been ſhewed in the laſt *Example*.

The Fourth Scituation.

PROBL. VII.

The Latitude *of two Places being given, together with the* Difference *of* Longitude, *To find,*

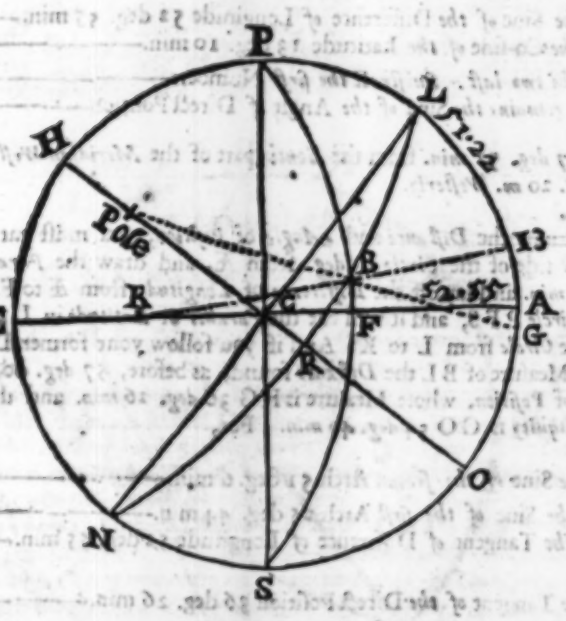
First, *The neareſt* Diſtance *in the* Arch *of a* Great Circle.

Secondly, *The* Direct Poſition *from the firſt Place to the ſecond.* And,

Thirdly, *From the ſecond Place to the firſt.* And,

Fourthly, *The* Circles *greateſt* Obliquity *that paſſeth over thoſe two Places.*

ADmit L be the *Latitude* of *Lundy* 51 *deg.* 22 *min.* and *Longitude* 25 *deg.* 52 *min.* and B is the *Latitude* of *Barbadoes* 13 *deg.* 10 *min.* and *Longitude* 332 *deg.* 57 *m.* and *Difference* of *Longitude* 52 *deg.* 55 *min.*



Lay down firſt the *Latitude* 51 *deg.* 22 *min.* from Q to L; ſecondly, the *Difference* of *Longitude* Q F 52 *deg.* 55 *min.* and draw the *Meridian-circle* P through F to S; then lay down the *Latitude* of *Barbadoes* from Q to 13, and take of the half

Tangent Line Q F 57 *deg.* 55 *min.* and lay from C to K, and draw the prick'd *Line*, and he will cut the *Meridian* P F S in B, the *Latitude* of *Barbadoes*, 13 *deg.* 10 *min.* through B draw the *Circle* L B N, ſo the *Angle* of *Poſition* is B L Q, whoſe meaſure is R O 67 *deg.* 51 *min.* that is, *W. S. W.* 21 *min. Weſterly*; which taken off the *Line* of half *Tangents* of your *Scale*, and laid from C to *Pole*, and draw the *Line* from *Pole* through B, and it will cut the *Limb* in G: Therefore meaſure G L on the *Line* of *Chords*, you have 57 *deg.* for the *Diſtance*, or 1140 *Leagues*, or 3420 *Miles*.

To find the *Diſtance* in *Queſtions* of this Nature,

1 *As the* Radius, *Is to the* Co-ſine *of the* Diff. *of* Longit. 52 d. 55 m. — 978030
So is the Co-tangent *of the greater* Latitude 51 deg. 22 min. — 990267
To the Tangent *of the firſt* Arch 25 deg. 44 min. — 968297

Take 25 *deg.* 44 *min.* from 76 *deg.* 50 *min.* the *Complement* of 13 *deg.* 10 *min.* the leſs *Latitude*, and the Remain is 51 *deg.* 6 *min.* the ſecond *Arch.*

2 *As the* Sine *of the firſt* Arch 25 d. 44 m. — 995464
Is to the Co-ſine *of the ſecond* Arch 51 d. 06 m. — 979793 } *To find the Diſtance.*
So is the Sine *of the greater* Latitude 51 d. 22 m. — 989273 }
1969066
To the Co-ſine *of the* Diſtance 57 d. 00 m. — 973602.

1306 *P.*
1157 *M.*
1140 *G.*
Leag. 17
166

which is the neareſt *Diſtance* in the *Arch* of a *Great Circle*, by 17 *Leagues* leſs than *Mercator's Chart* by the *Rhomb*, and leſs by 166 *Leagues* than by the *Rhomb* on the *Plain Chart*; which confirms this to be the neareſt of all ways of Sailing betwixt any two Places.

To find the *Angle* of *Poſition*,

3 *As the* Sine *of the* Diſtance 57 deg. 00 min. — 992359
Is to the Sine *of the* Difference *of* Longitude 52 deg. 55 min. — 990187
So is the Co-ſine *of the* Latitude 13 deg. 10 min. — 998843
Add the two laſt: Subſtract the firſt Numbers — 1989030
There remains the Sine *of the* Angle *of* Direct Poſition — 996681

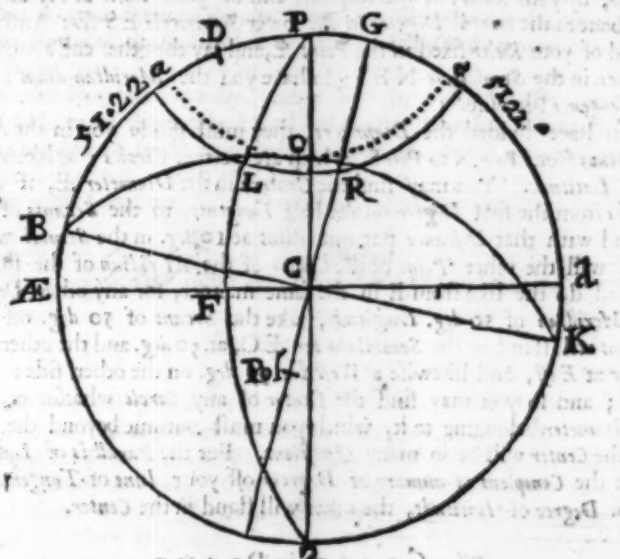
Which is 67 *deg.* 51 *min.* from the *South* part of the *Meridian Weſtward*, as namely, *W. S. W.* 20 *m. Weſterly.*

Now to know the *Diſtance* and *Angle* of *Poſition*, you muſt put *Barbadoes* at B, on the *Weſt* ſide of the *Circle* 13 *deg.* from Æ, and draw the *Parallel* of *Latitude* 51 *deg.* 22 *min.* and lay off the *Difference* of *Longitude* from Æ to F, and draw the *Meridian-circle* P F S, and it will cut the *Parallel* of *Latitude* in L; therefore from B draw the *Circle* from L to K: And if you follow your former Directions, B D will be the Meaſure of B L the *Diſtance* found, as before, 57 *deg.* 00 *min.* and L B P the *Angle* of *Poſition*, whoſe Meaſure is R G 36 *deg.* 26 *min.* and the *Great Circles* greateſt *Obliquity* is C O 54 *deg.* 40 *min.* For,

4 *As the* Sine *of the ſecond* Arch 51 deg. 6 min. — 989111
Is to the Sine *of the firſt* Arch 25 deg. 44 min. — 963767
So is the Tangent *of* Difference *of* Longitude 52 deg. 55 min. — 1012157
1975924
To the Tangent *of the* Direct Poſition 36 deg. 26 min. — 986813

From B towards L, which is 3 *Points*, 2 *deg.* 41 *min.* from the *Meridian*, namely, *N. E. b. N.* 2 *deg.* 41 *min. Eaſterly*, you muſt ſail firſt from B towards L; but alter your *Courſe*, ſtill increaſing toward the *Eaſtward*, as ſhall be ſhewed.

For



For the *Obliquity*, to find that,

5 *As* Radius,	*To* Co-ſine *of leſs* Latitude 13 deg. 10 min.	998843
So is the Sine *of the* Angle *of* Poſition 36 deg. 26 min.		977370
To the Co-ſine *of the greateſt* Obliquity 54 deg. 40 min.		976123

Theſe are the *Scituations* of all Places upon the *Terreſtrial Globe*; ſo that there cannot be any two *Queſtions*, but, in reſpect of each other, they will be found in one of theſe four kinds; except they fall in one *Meridian*, or on the *Æquator*: and theſe Directions you have in the Tenth *Chapter*: Therefore if you will ſeriouſly obſerve theſe ſhort Directions already given, and as follows, you ſhall never have your Expectation deceived.

CHAP. XII.

How to deſcribe the Globe *in* Plano, *by the* Mathematical Scale.

THeſe, and all other *Queſtions* of this nature, concerning the Reſolution of any *Spherical Triangle*, may very eaſily be performed by the *Globe*: But becauſe the *Globe* is a chargeable *Inſtrument*, and ſo every one cannot have it, therefore ſeveral Men, have for ſeveral Uſes, invented ſeveral ways to Project the *Globe* upon a *Plain*, as Mr. *Gunter* hath them in his Book of the *Sector*. The fitteſt for this purpoſe will be that of *Gemma Friſius*, which is moſt uſed in the *Great Maps* of the *World*, the Projection whereof is as followeth.

Firſt, By the *Chord* of 60 *deg.* deſcribe the *Circle* ÆNES, and by the *Chord* of 90 *deg.* divide it into four parts, as Æ E a *Croſs Diameter* for the *Æquator*, and N S for the great *Meridian*: Then by taking off every 10 *deg.* of the *Chord*, you may divide each *Quadrant* into 90 *deg.* and number them as in the *Figure*: Then if you take off your *Line* of ½ *Tangents* in your *Scale* every 10 *deg.* and 5 *deg.* and lay them from the *Center* C on the four Sides of the *Quadrants*, as you ſee the *Figure*, and number them as they are in the *Figure*; ſo ſhall you divide the *Diameters* into his parts Æ E the *Æquinoctial*, N S the *Meridian*, which are half *Tangents*. You may do it alſo without

out the *Scale*, by your *Ruler*, if you ſtop one end of your *Ruler* at N, and turn the other end about to the ſeveral *Degrees* in the lower *Semicircle* E S Æ: And alſo if you keep one end of your *Ruler* fixed in the *Point* Æ, and lay the other end about to the ſeveral *Degrees* in the *Semicircle* N E S; ſo have you the *Meridian-diameter* divided into half *Tangents* likewiſe.

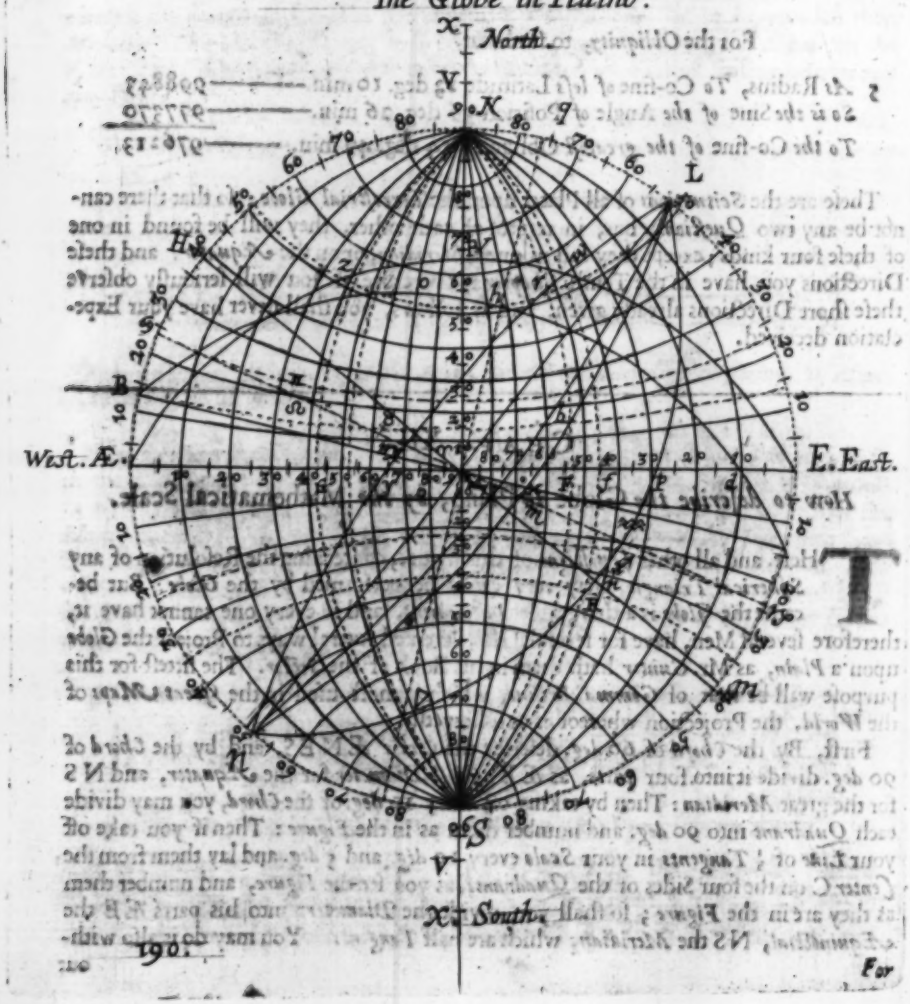
Now you have divided the *Diameters*, they muſt guide you in the drawing of the *Meridians* from *Pole* N to *Pole* S, which are perfect *Circles*; as likewiſe are the *Parallels* of *Latitude*. You may find the *Centers* in the *Diameter* Æ, if you extend the *Compaſſes* from the firſt *Degree* on the half *Tangents*, to the *Secants* of every 10 *Degrees*, and with that *Diſtance* put one *Point* at 10 *deg.* in the *Semidiameter* Æ C, and in E C will the other *Point* be the *Center* of the *Meridian* of the firſt 10 *deg.* from Æ: and do the like from E in the ſame manner, for any other *Degree*. To draw the *Meridian* of 50 *deg. Longitude*, take the *Secant* of 50 *deg.* off the *Scale*, and one *Point* will ſtand in the *Semidiameter* Æ C, at 50 *deg.* and the other will ſtand in the *Center* at *Eaſt*, and likewiſe at *Weſt* for 50 *deg.* on the other ſide: And ſo do for the reſt; and ſo you may find the *Center* of any *Circle* whatſoever, upon the Croſs *Semidiameter* belonging to it, which you muſt continue beyond the *Great Circle*, where the *Center* will be in many *Queſtions*. For the *Parallels* of *Latitude*, it is thus: Take the *Complement-number* of *Degrees* off your *Line* of *Tangents*, put one *Point* in the *Degree* of *Latitude*, the other will ſtand in the *Center*.

How to find the Centers *of the* Meridian-circles.

How to find the Centers *of the* Parallels *of* Latitude.

The GLOBE *in* PLANO.

The Globe in Plano.



For Example. If you will draw the *Parallel* of *Latitude* for 60 *deg.* take off the *Tangent-line* of your *Scale* 30 *deg.* the *Compl.* of 60 *Latitude*, and the other will fall upon V the *Center* of the *Parallel* of 60 *deg.* in the *Semidiameter* N S continued beyond the *Circle*.

So, Take the *Tangent* of 40 *deg.* and it will draw the *Parallel* of 50 *deg.* whose *Center* is at ♈: and so do in drawing all *Parallels* of *Latitude*. You may draw them also by making several Trials, until your three *Points* be in a *Circle*, and also draw the *Parallels* of *Latitude*: with the same *Distance* find their *Centers*; but if you can, by the *Scale* is the surest way.

The Four Situations *that are in the* Globe.

The First Situation.

Æ is a *Point* of *Intersection* for the Mouth of the *River* of *Amazones*, Z *Lundy*, C R V the *Obliquity* 62 *deg.* 16 *min.* E the other *Point* of *Intersection* with the *Æquator*, N R V the measure of the *Angle* of *Position*. which applied to the *Æquator* from Æ inwards, shews you 27 *deg* 50 *min.* from *Amazones* to *Lundy*. Now if you will know the *Distance* in such *Questions*, measure it in the *Meridian* that agrees with the *Angle* of *Position*; as namely, for this *Distance* Æ Z, you must measure from N in the *Meridian-line* of 27 *deg.* 50 *min.* and you will find it 61 *deg.* 57 *min.* And so do for to measure any other *Distance*.

The Second Situation.

I is the first Places *Latitude*, ♈ is the *Difference* of *Longitude* 52 *deg.* 55 *min.* ♈ is likewise the second Places *Latitude*; and ♍ H is the measure of the *Angle* of *Position*, which measured in the *Semidiameter* Æ C, will be found 68 *deg.* 46 *min.* In that *Meridian* measure I r the *Distance*, and you will find it from N towards C, to reach 32 *deg.* 18 *min.* Remember to measure the *Distances* from the *Poles* in the same *Meridian*, of the Number of *Degrees* of the *Angle* of *Position*: The greatest *Obliquity* of that *Circle* N r I is at W 54 *deg.* 25 *min.* *Intersection* of the *Æquator* at Y, W is a *Meridian* of greatest *Obliquity*.

The Third Situation.

L is the first Places *Latitude* 51 *deg.* 22 *min.* *North*; E p is the *Difference* of *Longitude* 45 *deg.* 55 *min.* R is the second Places *Latitude*, or *Rio de Plata*, △ the greatest *Olliquity* 68 *deg.* 22 *min.* m n the Measure of the *Angle* of *Direct Position*: applied to E C will be found 36 *deg.* 02 *min.* in that *Meridian*: from the *Pole* measure the *Distance* L R, and you will find it 95 *deg.* 18 *min.* P the *Intersection* of the *Great Circle*, passing over the two Places in the *Æquator*.

The Fourth Situation.

The first *Latitude* is at L *Lundy* 51 *deg.* 22 *min.* *Difference* of *Longitude* counted from E 52 *deg.* 55 *min.* that *Meridian* will cut the *Latitude* of *Barbadoes* 13 *deg.* 10 *min.* at b: M ♈ the Measure of the *Angle* of *Direct Position* 67 *deg.* 51 *min.* and b L measured in that *Meridian* is 57 *deg.* 00 *min.* the *Distance*. Now to know the *Angle* of *Position* from *Barbadoes*, being *Westward* from *Lundy*, set it on the *West* side of the *Figure*; as at B; and likewise if the first Place be to the *Eastward*, put his *Latitude* to the *East* side of the *Meridian*.

Now to know the *Angle* of *Position* from *Barbadoes*, and *Distance*, and *Obliquity*, B □ O is the *Arch* of the *Great Circle* that passeth over these two Places; □ is *Lundy*, q h is the Measure of the *Angle* of *Position* 36 *deg.* 26 *min.* B □ measured in that *Line*,

Line, you will find the *Diſtance* 57 *deg.* O is the greateſt *Obliquity* 54 *deg.* 40 *min.* N O ⊙ S a *Meridian* of the greateſt *Obliquity*: d is the *Interſection* with the *Æquator*.

Chap. XIII.

By Arithmetick *how to Calculate exactly for any* Degrees *and* Minutes *of* Obliquity; *what* Degree *and* Minute *of* Latitude *the* Great Circle *ſhall paſs through for any* Degree *and* Minute *of* Longitude, *from the* Point *of* Obliquity, *or of its* Interſection *with the* Æquinoctial.

NOte theſe *Rules* well, for they ſerve for all *Queſtions* of this nature, what *Difference* of *Longitude* ſoever any Point or Place hath from the *Meridian* of its next *Obliquity*, which is ever 90 *deg.* or leſs; the *Complement* thereof to 90 *deg.* is the *Difference* of *Longitude* of that Point or Place, from the *Meridian* of that *Great Circle's* next *Interſection* with the *Æquator*.

The firſt ſort of Rules are theſe.

By the Latitude *of two Places, the* Difference *of* Longitude *betwixt them, and the* Obliquity *of the* Great Circle *paſſing directly over both Places given; To find the* Difference *of* Longitude *of each Place from the* Meridian *of the greateſt* Obliquity.

Let this be our *Example*. *Lundy* in *North Latitude* 51 *deg.* 22 *min.* and *Barbadoes* in *North Latitude* 13 *deg.* 10 *min.* and *Difference* of *Longitude* 52 *deg.* 55 *min.* and the greateſt *Obliquity* 54 *deg.* 40 *min.* Work firſt with the leſs *Latitude*, to find the *Difference* of *Longitude* from the *Meridian* of *Obliquity* of both Places.

Rule I.

Thus, *As* Radius, *and* Co-tangent *of* Obliquity 54 deg. 40 min.—1, 985059
Take from it the Co-tangent *of leſs* Latitude 13 deg. 10 min.-1, 063090
There remains the Co-ſine *of* Differ. *of* Longitude 80 d. 27 m.- 921969

The *Difference* of *Longitude* of the ſecond Place from the *Meridian* of the greateſt *Obliquity*. And by reaſon the *Difference* of *Longitude* from the *Obliquity* is more than the *Difference* of *Longitude* betwixt the two Places, therefore ſubſtract the *Difference* of *Longitude* 52 *deg.* 55 *min.* from 80 *deg.* 27 *min.* and there remains the *Difference* of the firſt Place from the *Meridian* of *Obliquity* 27 *deg.* 32 *min.* and the firſt Place is betwixt the ſecond Place and the *Meridian* of *Obliquity*. But if the *Difference* of *Longitude* from *Obliquity* had been leſs than the *Difference* of *Longitude* betwixt the two Places, then ſubſtract the *Longitude* from the *Difference* of *Longitude* betwixt the two Places, and the Remain had been the *Difference* of *Longitude* from the *Meridian* of *Obliquity*, to the firſt Place.

The Uſe of theſe *Rules* are,

1. To find where to place the *Meridian* of the greateſt *Obliquity* betwixt any two Places, in a blank *Chart*, or *Mercator's Chart* or *Plat*, to trace out the *Voyage*, as we find that it is 80 *deg.* 27 *min.* the *Difference* of *Longitude* of the ſecond Place from the *Meridian* of *Obliquity*, and 27 *deg.* 32 *min.* from the firſt.
2. You ſee you find the *Difference* of *Longitude* betwixt the *Obliquity* and any *Latitude* propounded, by the laſt *Rule*.
3. By the *Obliquity* of the *Great Circle*, and the *Difference* of *Longitude* from the *Obliquity*, to find the true *Latitude*.

Rule

RULE II.

As Radius, *To* Co-tangent *of* Obliquity 54 deg. 40 min. ——— 1985059
Take from it the Co-sine *of* Differ. *of* Longitude 80 deg. 27 min. —— 921086
There remains Co-tangent *of the* Latitude 13 deg. 10 min. ——— 1063973

And so likewise if you work with 27 *deg.* 32 *min.* by the same *Rule*, you will find the other *Latitude* 51 *deg.* 22 *min.* and by it find from any Place through what *Latitude* the *Great Circle* passeth every 10 *deg.* or 5 *deg.* or more or less Quantity of *Longitude* from the *Obliquity*; and thereby find the *Latitude*, to make marks in every *Meridian*, and so trace out the *Great Circle Arch*, in your *Mercator*, or Mr. *Wright's Plat* or *Blank Chart*.

As thus, for 2 *deg.* 28 *min.* of *Longitude* more, added to 27 *deg.* 32 *min.* makes 30 *deg.* 00 *min.*

RULE III.

As Radius, *To* Co-tangent *of* Obliquity 54 deg. 40 min. ——— 1985059
Take from it the Co-sine *of* Differ. *of* Long. *from* Obliq. 30 d. 00 - 993753
There remains the Co-tangent *of the* Latitude 50 deg. 41 min. — 991306

And by the same *Rule* I made this *Table*, of an *Arch* of a *Great Circle*, extended from *Latitude* 51 *deg.* 22 *min.* to *Latitude* 13 *deg.* 10 *min.* *Difference* of *Longitude* 52 *deg.* 55 *min.* setting the *Point* of the greatest *Obliquity* upon a *Meridian-line*, that so it might be the better protracted on *Mercator's Chart*: This is, for every 15 *deg.* *Difference* of *Longitude*, these are the *Latitudes* the *Great Circle* will pass through; so that you see there is 52 *deg.* 55 *min.* added by 5 to the *Difference* of *Longitude* of the first Place from the *Meridian* of *Obliquity*, which makes 80 *deg.* 27 *min.* the *Difference* of *Obliquity* of the second Place, which was the *Difference* of *Longitude* from *Obliquity* at first found. In like manner work for any other Place.

Differ. of Longit. from Obliq. Lundy		Latitude from Lundy.		
Deg.	Min.	Deg.	Min.	
27	32	51	22	
30	00	50	41	
35	00	49	07	
40	00	47	13	
45	00	44	56	
50	00	42	12	
55	00	38	58	
60	00	35	12	
65	00	30	48	
70	00	25	46	
75	00	20	03	
80	27	13	10	*Barbadoes.*

CHAP. XIV.

How by the Scale *of* Tangents *to make a Part of the* Globe *in* Plano, *whereby you may trace out the* Latitudes *to every* Degree *of* Longitude; *or every* 5 *or* 10 Degrees, *as neer as you will desire, without Calculation.*

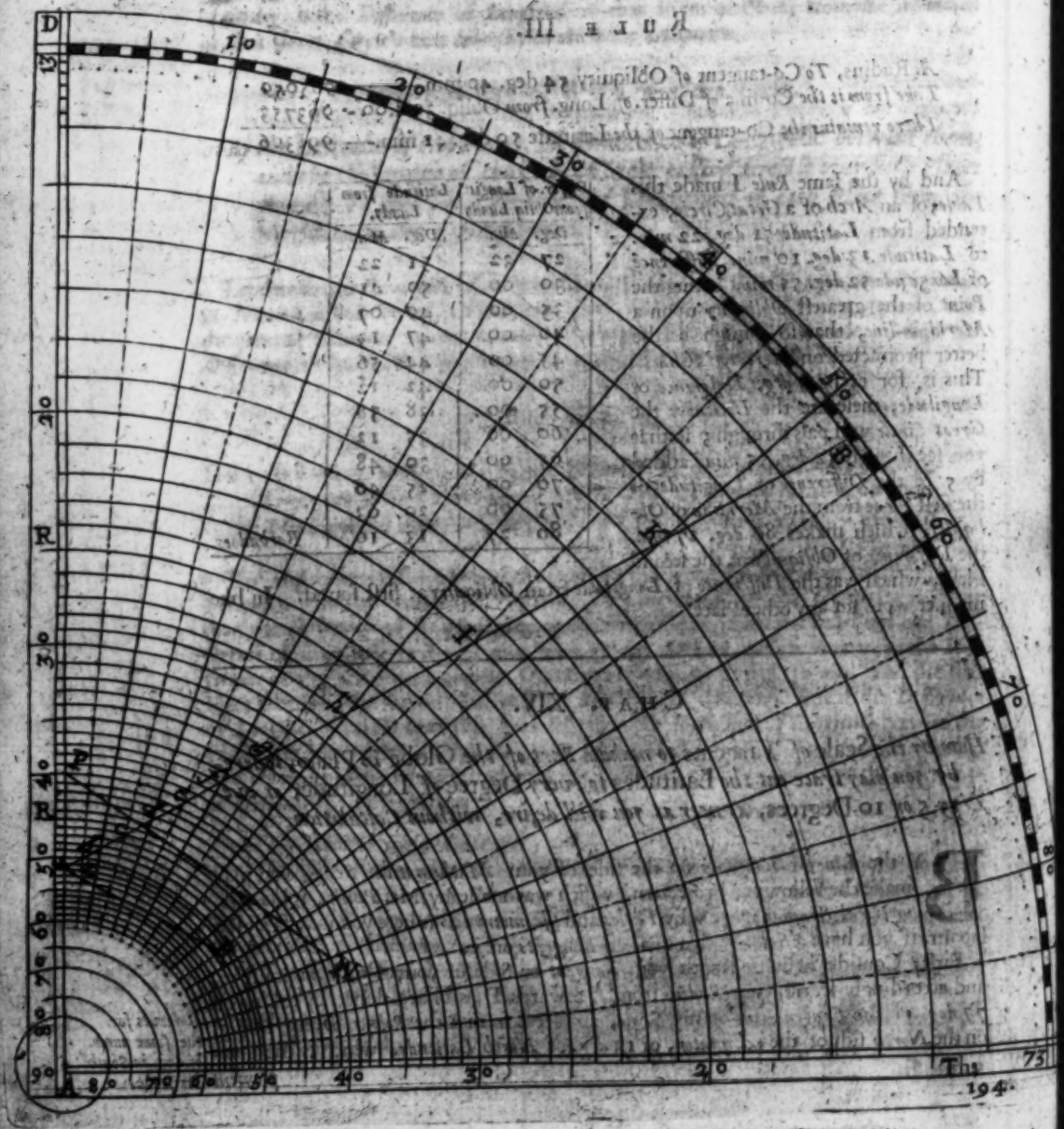
BY the *Line* of *Tangents* on the side of your *Mathematical Scale*, you may make the following Projection, which was made by Mr. *Philips* in his *Geometrical Seaman*, *pag.* 5. by *Tables* and *Geometry*: But here you may save that labour, if you have a *Scale* with a *Line* of *Tangents* on it.

First, Consider of what length your *Tangent* or Side of your *Quadrant* must be, and accordingly set off your *Radius* from A towards D, as I have done, by taking off 77 *deg.* of the *Tangent-line* of my *Scale*, and set it from A the *Pole* to D, for 13 *deg.* on the *North* side of the *Æquator*, or 13 *deg.* of *North Latitude*, which is the *Complement*

It serves for the same numb. of deg. in South Latitude.

plement of 77 to 90 *deg.* Then make the other side of the same length, and draw the *Quadrant* A D E, the *Radius* is always a *Tangent* of 45 *deg.* Then with your *Compasses* take off the *Line* of *Tangents* the several *Degrees*, and draw the *Arches* or *Parallels* of *Latitude*, as you see I have done in the *Figure*. Thirdly, divide the *Limb* of the *Arch* D E into 90 *deg.* and through every 5 or 10 *deg.* draw *Lines* of *Longitude*, or *Meridian-lines*. The *Arches* of *Latitude* must be numbered as in the *Figure*; but the *Lines* of *Longitude* you may number from either side, as occasion requires.

You may, if you will, when occasion requires, divide a *Circle* into four *Quadrants*, and draw the *Lines* of *Longitude* from the *Center*; and you may make this as large or as little as you will, by the *Tables* of *Natural Tangents* in the Second Book, as you have been there shewed how to lengthen or shorten your *Radius*: You may number the whole *Circle* of *Longitude* into 360 *deg.*



The *Blank Quadrant*, being thus made, will serve for many *Examples*; especially if you make it upon a *Slat Stone*, that you may wipe the Arch, that is lightly drawn by a *Slat Pen* betwixt any two Places, off at pleasure.

You may set down therein the two Places you are to sail between, according to their *Latitudes* and *Longitudes*; and then only by your *Ruler* draw a streight *Line* from the one Place to the other, which will represent the *Great Circle* which passeth between the two Places, and will cut those *Degrees* of *Longitude* and *Latitude*, which you must sail by exactly. You may do it by the *Difference* of *Longitude* only, if you will, as shall be shewed in this *Example*, for proof thereof.

Of a *Voyage* from *Lundy*, in *Latitude* 51 *deg.* 22 *min.* and *Barbadoes*, in *Longitude* 332 *deg.* 27 *min. Difference* 52 *deg.* 55 *min.* and *Latitude* 13 *deg.* 10 *min.* To find by what *Longitude* and *Latitudes* the *Arch* of a *Great Circle* drawn between those two Places doth pass.

First, Let the *Line* A D represent the *Meridian* of the *Island* of *Lundy*, marked out by L for its *Latitude* 51 *deg.* 22 *min.* and the *Longitude* thereof 25 *deg.* 52 *min.* at D, which is set down according to its *Longitude* and *Latitude*. Then from D in the *Limb* or *Arch* of the *Quadrant*, count the *Difference* of *Longitude* 52 *deg.* 55 *min.* and this is the *Meridian* of the *Island* of *Barbadoes*, on which you must mark out the *Latitude* 13 *deg.* 10 *min.* at B; lay a *Ruler* from the first *Latitude* L to the second at B, and draw the streight *Line* LB, which representeth the *Arch* of a *Great Circle* between the two Places; and if you guide your Eye along in this *Line*, you may readily and truly perceive by what *Longitudes* and *Latitudes* you should sail: For where this *Line* crosseth the *Arches* of *Latitude* and the *Lines* of *Longitude*, that shews the true *Longitude* and *Latitude* of the *Arch*, according to your desire. Now the truth hereof will more evidently appear, if you compare the *Latitudes* and *Longitudes* which this *Line* intersecteth, with this *Table*, as before, Calculated by me for every 1 *deg.* of *Longitude*. You may see by the *Figure*, that the *Line* B L in the *Points* a, b, c, d, e, f, g, h, i, k, L, doth cross the *Parallel* of *Latitude*, as you see in the fourth *Column* of this *Table*, at the same number of *Degrees* from the first *Meridian*, as you set in the fifth *Column*. The first *Column* is the Number of *Degrees* of *Longitude*, the second is the *Differences* substracted, the third is the *Degrees* of *Longitude* from the *Meridian* of the greatest *Obliquity*, the fourth and fifth are as before, *Latitude* and *Longitude* added, for the *Difference* of *Longitude* from *Lundy*. *For Example*, I would know what *Degree* of *Latitude* 47 *deg.* 28 *min.* of *Longitude* from the first *Meridian* doth cross; and I see by the *Figure* it is at 10 *deg.* of *Longitude*, which the *Table* sheweth is 10 *deg.* 38 *m.* of *Latitude*, and so of the rest, 75 *deg.* from *Meridian* of *Obliquity* and *Longitude* 338 *deg.* 24 *min.*

Differ. of Longit. substract		*Differ. of Longit. from Obliqu.*		*Latitude*		*Differ. of Longit. added.*	
D.	*M.*	*D.*	*M.*	*D.*	*M.*	*D.*	*M.*
52	55	27	32	51	22	00	00
2	28	30	00	50	41	02	28
5	00	35	00	49	07	07	28
5	00	40	00	47	23	12	28
5	00	45	00	44	36	17	28
5	00	50	00	42	12	22	28
5	00	55	00	38	58	27	28
5	00	60	00	35	12	32	28
5	00	65	00	30	46	37	28
5	00	70	00	25	46	42	28
5	00	75	00	19	39	47	28
5	27	80	27	13	10	52	55
52	55			*Barbad.*			

And so in like manner you may lay down upon the former *Quadrant* any two Places, howsoever scituated, by their *Longitude* and *Latitude*, or *Difference* of *Longitude*, in the manner as you have been shewed in the last *Example*.

You may measure the Distances thus. Take B L *the Distance of the two Places, and put it upon the Meridian* B Z *of* Barbadoes, *the second Place, & you will find the Parallels of Latitude to be* 57 *d. the true Distance, as before found.*

Chap. XV.

Rule IV.

How by the Latitude well observed, and the Rhomb discreetly rectified, to find the Latitude, Rhomb, and Longitude, and Distance, having two of them known, by an Arithmetical Rule, and by them to prick the same down in a Blank Chart or Mercator's Plat.

By the Latitude, *and* Difference *of* Longitude *from the* Obliquity, *to find the true* Great Circle's Distance.

As Radius 90, *To* Co-sine *of the* Latitude 51 deg. 22 min. —— 979541
So is the Sine *of the* Difference *of* Longitude 27 deg. 32 min. —— 966489
To the Sine *of the* Distance 16 deg. 47 min. —— 946030

So that 16 deg. 47 min. is the *Great Circle's Distance* from the *Point* of the greatest *Obliquity* of that *Great Circle*.

Rule V.

By the Obliquity *of the* Great Circle, *to find the true* Latitude *to any Quantity of a* Great Circle's Distance, *from the* Point *of his greatest* Obliquity.

As Radius, *To* Sine *of greatest* Obliquity 54 deg. 40 min. —— 991158
So is Co-sine *of the* Distance *from* Obliquity 16 deg. 47 min. —— 998109
To the Sine *of the true* Latitude 52 deg. 22 min. —— 989267

Again,

As Radius, *To* Sine *of greatest* Obliquity 54 deg. 40 min. —— 991158
So is Co-sine *of* Distance *from* Obliquity 73 deg. 47 min. —— 944602
To Sine *of true* Latitude *of* Barbadoes 13 deg. 10 min. —— 935760

Rule VI.

By the Great Circle's Distance *from the* Point *of* Obliquity, *and the* Latitude *given*; *To find the* Difference *of* Longitude *between the Place and the* Meridian *of greatest* Obliquity.

As Radius, *To the* Sine *of* Distance *from* Obliquity 16 d. 47 m. —— 946052
Take from it the Co-sine *of the* Latitude 51 deg. 22 min. —— 979541
Remains the Sine *of* Difference *of* Longitude 27 deg. 33 min. —— 966511

By these four last *Rules* you may be confirmed of the truth of the former Work, of tracing of the *Great Circle* by *Longitude*, *Latitude*, and *Distance*, from the *Point* of its greatest *Obliquity*.

That is worth your Observation, That the *Complement* to 90 *Degrees* of the *Great Circle's Distance* of a Place from the *Point* of the *Great Circle's Obliquity*, is always the *Great Circle's Distance* from the *Point*, wherein that *Circle* intersecteth the *Equinoctial*.

The ſecond ſort of RULES;

whereby to find what Rhomb *you are to ſail upon, that you may keep in or neer the* Arch *of a* Great Circle, *extended from one Place to another.*

RULE VII.

By the Difference *of* Longitude *from the* Obliquity, *and* Latitude *given; To find the* Great Circle's Diſtance *from the* Point *and* Meridian *of greateſt* Obliquity.

As Radius, *To the* Sine *of* Difference *of* Longitude *from* Obliquity 80 deg. 27 min.	999193
So is Co-ſine *of the* Latitude 13 deg. 10 min.	998843
To the Sine *of the* Great Circle's Diſtance *from* Obliq. 73 d. 47 m.	998236

So that if you take out 16 *deg.* 47 *min.* in the *Diſtances* of *Obliquity* before found out of 73 *deg.* 47 *min.* the Remain will be the true *Diſtance* of the two Places 57 *deg.* as was found in the ſecond *Rule* of the fourth *Scituation.* But if the *Point* of greateſt *Obliquity* had been betwixt the two Places, you muſt have added them together, and the ſame had been the *Diſtance* of the two Places.

RULE VIII.

By the Great Circle's Diſtance *from the* Obliquity, *and the* Latitude *given; To find the* Rhomb.

As Radius 90 d. *and* Tang. *of* Great Circle's Diſtance 16 d. 47 m.	947943
Take out the Co-tangent *of the* Latitude 51 deg. 32 min.	990267
There remains the Co-ſine *of the* Rhomb 67 deg. 50 min.	957676

Having therefore in the four *Scituations*, before-going, been directed how to find the *Diſtance* betwixt the two Places, by the *Arch* of a *Great Circle*, and the greateſt *Obliquity* of any *Circle*, you may by the firſt *Rule* of *Chap.* 13. find the *Difference* of *Longitude* of each Place, from the *Point* of the *Great Circle's* greateſt *Obliquity*; and then by the fourth and ſeventh *Rules* of *Chap.* 15. find the *Great Circle's Diſtance* to the *Obliquity*, and by the eighth *Rule* find the *Rhomb* to be ſailed on, from either Place towards the other.

RULE IX.

To find how far a Man ſhould ſail upon a Rhomb, *before he change his* Courſe 1 Point, Half 1 Point, *or a Quarter of* 1 Point.

You may try this by your Protracting *Quadrant*, or your *Blank Plan* or *Chart*, made according to Mr *Wright's* or *Mercator's* Projection; where the *Voyage* is truly and carefully traced out as before.

Or you may *Arithmetically* try every *Point*, or Quarter of a *Point*, or Half *Point*, as you ſee cauſe, by theſe *Rules*.

Having found by the eighth *Rule* the *Rhomb* was 67 *deg.* 50 *min.* add to it a Quarter of a *Point*, or 2 *deg.* 29 *min.* it makes 70 *deg.* 19 *min.* *W. N.W.* ¼ *W.* and *Latitude* 49 *deg.* 07 *min.* and *Difference* of *Latitude* 2 *deg.* 15 *min.* and it is required the *Diſtance.*

As

As Radius 90 deg. *To* Sine *of* Difference *of* Latitude 2 d. 15 m.—859394
Take out the Co-sine *of the* Rhomb 70 deg. 19 min.——952739
There remains the Sine *of the* Distance 06 deg. 42 min.——906655.

Therefore 06 *deg.* 42 *min.* is 134 *Leagues*, may be sailed *W. N. W.* ½ *Westerly*, from the *Latitude* 51 *deg.* 22 *min.* to *Latitude* 49 *deg.* 07 *min.*

Rule X.

By the Great Circle's Distance, *and the* Difference *of* Latitude *given*; *To find the* Rhomb.

As Radius, *To* Sine *of* Difference *of* Latitude 2 deg. 15 min.——859394
Take out the Sine *of the* Distance 6 deg. 42 min.——906655
There remains the Co-sine *of the* Rhomb 70 deg. 19 min.——952739

Rule XI.

By the Rhomb, *and* Distance *upon it given*, *To find the* Difference *of* Latitude.

As Radius, *To* Co-sine *of the* Rhomb 70 deg. 19 min.——952739
So is Sine *of the* Distance 06 deg. 42 min.——906655
To the Sine *of* Difference *of* Latitude 2 deg. 15 min.——859394

Which 2 *deg.* 15 *min.* taken from the first *Latitude* 51 *deg.* 22 *min.* there remains the *Latitude* 49 *deg.* 07 *min.* which are good Proofs.

Rule XII.

By the Obliquity *of the* Great Circle, *and the* Latitude *given*; *To find the* Difference *of* Longitude *from the* Meridian *of* Obliquity.

As Radius 90, *To* Co-tangent *of* Obliquity 54 deg. 40 min.——985059
Take out the Co-tangent *of the* Latitude 49 deg. 07 min.——992737
There remains Co-sine *of* Difference *of* Longitude 35 deg. 00 m.——991322

35 *deg.* 00 *min.* is the *Difference* of *Longitude* from the *Meridian* of *Obliquity*. You you may also try it by the *Difference* of *Longitude* in the fifth *Column*, 7 *deg.* 28 *min.* in the foregoing *Table*, added to 27 *deg.* 32 *min.* makes 35 *deg.* as before.

Rule XIII.

By the Latitude, *and* Difference *of* Longitude *from the* Obliquity *given*; *To find the* Great Circles Distance *from the* Meridian *of* Obliquity.

As Radius, *To* Co-sine *of the* Latitude 49 deg. 07 min.——981593
So is the Sine *of the* Difference *of* Longitude 35 deg. 00 min.——975859
To the Sine *of the* Distance 32 deg. 05 min.——957452

Which is the *Distance* from the *Meridian* of the greatest *Obliquity*: Then you may proceed to the *Rhomb* next to be sailed on.

Now if you add 2 *deg.* 49 *min.* to the former *Rhomb* 70 deg. 19 *min.* it makes 73 *deg.* 8 *min.* that is *W. S. W.* half a *Point Westerly*, and the *Difference* of *Latitude* 4 *deg.* 11 *min.* which you may find by the foregoing *Tables*, or thus by the ninth *Rule*.

Rule

RULE XIV.

As Radius, *Is to* Co-ſine *of* Difference *of* Latitude 4 deg. 11 m.—886301
Take out the Co-ſine *of the* Rhomb 73 deg. 08 min.———— 946261
There remains the Sine *of the* Diſtance 14 deg. 34 min.———— 940040

Which 14 *deg.* 34 *min.* converted into *Leagues* is 291 *Leagues* $\frac{1}{2}$ the *Diſtance* you may ſail *W. S. W.* $\frac{1}{2}$ a *Point Weſterly*, from *Latitude* 49 *deg.* 07 *min.* to *Latitude* 44 *deg.* 56 *min.* and the *Difference* of *Longitude* is 10 *deg.* as you may ſee by the former *Table*, by the *Latitude* 44 *deg.* 56 *min.* is 17 *deg.* 28 *min.* and the *Difference* of *Longitude* from *Obliquity* is 45 *deg.* 00 *min.* and the *Longitudes* according to my *Globes* made by *Hondius* 8 *deg.* 24 *min.* and ſo work until you have calculated the *Diſtance* for every $\frac{1}{4}$ *Point*, or rather half *Point*, becauſe $\frac{1}{4}$ of a *Point* cannot be well ſteered upon. It is no matter if you do not exactly keep the *Arch* of a *Great Circle*, for the Reaſons before given: but as neer to it as you may conveniently, as Mr. *Norwood* hath ſufficiently anſwered in his ninth *Problem* of *Sailing by a Great Circle*.

But let me adviſe you to get into your *Latitude* ſhort of the Place you are bound to, for fear of miſtakes in your *Reckoning*, and ſo over-ſhoot your *Port* to a greater diſgrace, than the credit of *Great Circle Sailing* will bring you; and then to know what *Diſtance* you are to ſail in that *Parallel* of *Latitude*.

RULE XV.

By the Latitude, *and* Difference *of* Longitude *given*: *To find the* Diſtance *upon a* Courſe *of* Eaſt *or* Weſt.

As Radius, *Is to* Co-ſine *of the* Latitude 13 deg. 10 min.—— 998843
So is the Sine *of* Difference *of* Longitude 5 deg. 00 min.———— 894029
To the Sine *of the true* Diſtance 4 deg. 52 min.———— 892872
which is 97 *Leagues* $\frac{1}{2}$.

After you have made ſome progreſs in your *Voyage*, you may make uſe of theſe moſt excellent *Rules*, whereby a *Mariner* may make his Concluſion moſt certain.

RULE XVI.

By the Difference *of* Latitude, *and* Rhomb *ſailed on*; *To find the* Diſtance. You have it in the Fourteenth *Rule* before-going.

RULE XVII.

By the Latitude, *and* Diſtance *ſailed upon an* Eaſt *or* Weſt Courſe, *To find the* Difference *of* Longitude; *as* 20 Leagues *ſailed in* Latitude 51 deg. 22 min.

As Radius, *To* Sine *of the* Diſtance 1 deg. 00 min.———— 1824185
Take away Co-ſine *of the* Latitude 51 deg. 22 min.———— 979541
Remains the Sine *of* Difference *of* Longitude 1 deg. 36 min.—— 844644

Therefore ſailing 20 *Leagues Eaſt* or *Weſt* in the *Parallel* of 51 *deg.* 22 *min.* the *Difference* of *Longitude* made is 1 *deg.* 36 *min.* which is a good *Rule* when you are in the *Latitude* of the Place you are bound to. In the firſt *Rule* you have how for to find the *Difference* of *Longitude* from *Obliquity*, *Chap.* 13. and likewiſe in *Rule* 12. where the *Difference* of *Longitude* is 35 *deg.* ſubſtract it from 27 *deg.* 32 *min.* and the *Remain* will be the *Difference* of *Longitude* of two Places, one in *Latitude* 51 *d.* 22 *min.* the other 49 *deg.* 07 *min.* as you have been directed before.

So

So that what hath been written will ſatisfie any ingenious Spirit, to make uſe of theſe *Rules* in theſe four *Scituations*, and theſe four will anſwer any thing required, in all ſorts of *Great Circle* ſailing. I ſhall now make the blank *Mercator Plat*, and trace out the *Arch* of a *Great Circle*, and likewiſe ſhew how by *Latitude* and *Longitude* to find the Place of any *Ship* in *Mercator's Chart*.

Chap. XVI.

How to make the moſt true Sea-Chart, *and the Uſe thereof in* Mercator's *and* Great Circle *Sailing, called a* General Chart.

FOr the manner of the *Diviſion*, Let the *Æquator* be drawn and divided, and croſſed with *Parallel-Meridians*, as before directed; only one *Degree* of *Longitude* in the *Particular Chart* before-going, is 10 *deg.* of the *Æquator* of this *General Chart*. You have been directed how to make the *Meridian-line* off the *Scale* which is for a *General Chart*; and the ſame *Rule* makes this. Look in the *Table* of *Meridional parts*, and you will find the *Difference* between the *Æquator* and 40 *deg.* of *Latitude* in the *Meridian-line* to be 874,2 which is 874 *Leagues* and $\frac{2}{10}$; that divided by 20 is 43 *deg.* 42 *min.* $\frac{1}{10}$ of the *Æquator*, therefore take out of a *Scale* of *Equal parts*, anſwerable to each *Degree* of the *Æquator*, divided into 20, which you muſt reckon 200 *Parts*, take 874 *Parts*, and that *Diſtance* will reach from the *Æquator* to 40 *deg.* of *Latitude*. Always remember in a *General Chart* to omit the laſt *Figure* in the *Table*, which is *Tenths*, $\frac{1}{10}$ in this.

And for 50 *deg.* take 1158 ſuch *Equal parts*, which is 57 *deg.* 54 *min.* will reach from the *Æquator* at Æ, to 50 *deg.* of *Latitude* in the *Meridian-line*: And ſo do for any other *Degree* or *Minute* of *Latitude*, until you have made the *Chart*, as I have done the *Figure* following.

How to make the Meridian-line by the former Geometrical Projection.

You may divide the *Meridian-line* by the *Projection* in the *Quadrant*, making the ſide thereof anſwerable to 5 *Degrees* of the *Æquator* of the *Chart*, as in this.

Suppoſe you would know the *Diſtance* betwixt 40 *deg.* and 50 *deg.* of *Latitude*, in the *Meridian-line* of a *Chart*.——Take the middle of 10 *deg.* which is 45 *deg.* out of that *Latitude* in the *Quadrant*, and it will reach from 40 to 50 *deg.* of *Latitude* in the *Chart*, which you may ſoon try. And ſo work for any other *Latitude*.

A Scale of Leagues.

You have alſo there a *Scale* of *Leagues* for every *Parallel* of *Latitude*, to meaſure any *Diſtances* in the *Chart*; for every *Degree* is 200 *Leagues* in this *Chart*, as you may ſoon apprehend, without more words, by the former Directions.

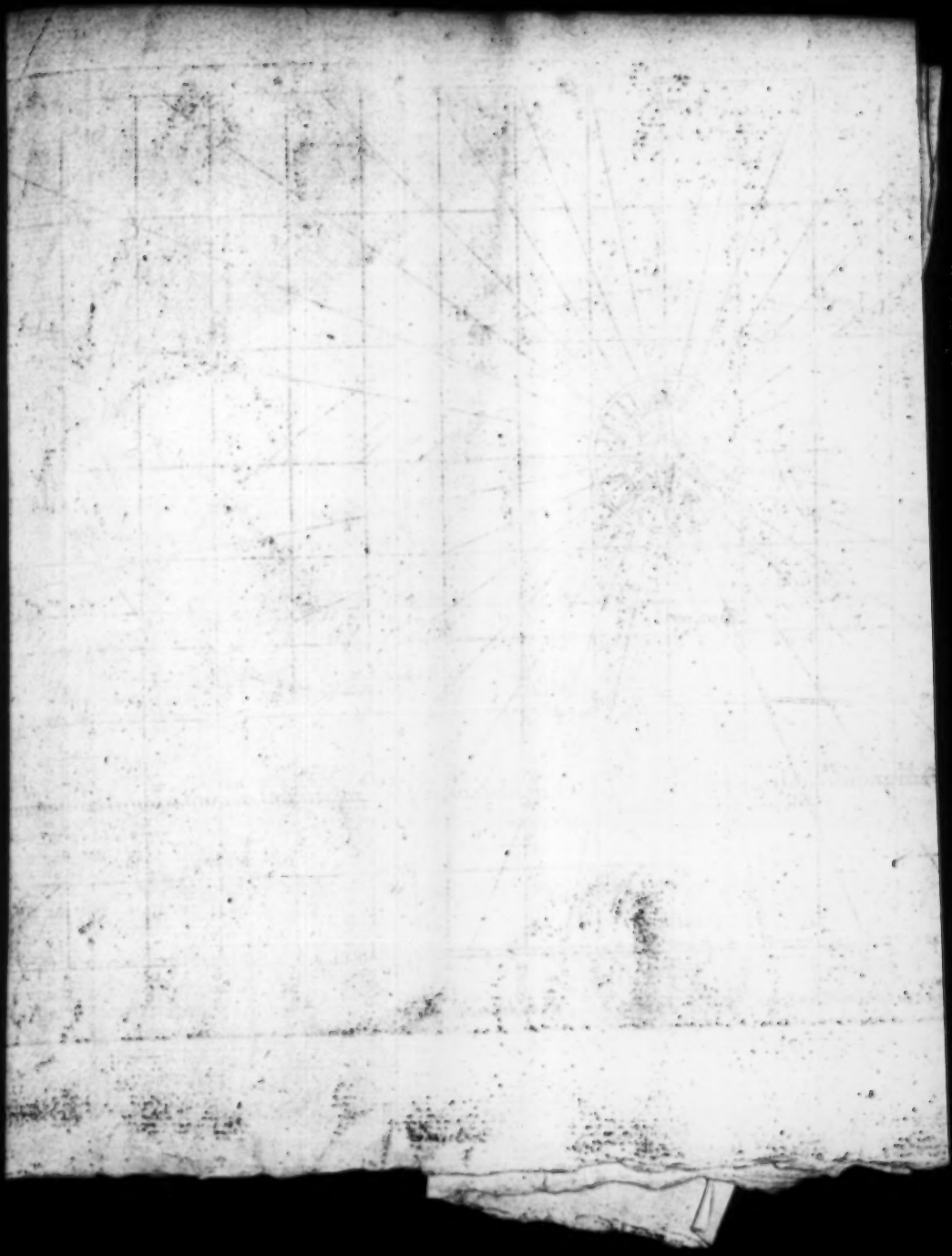
The Protracting Quadrant.

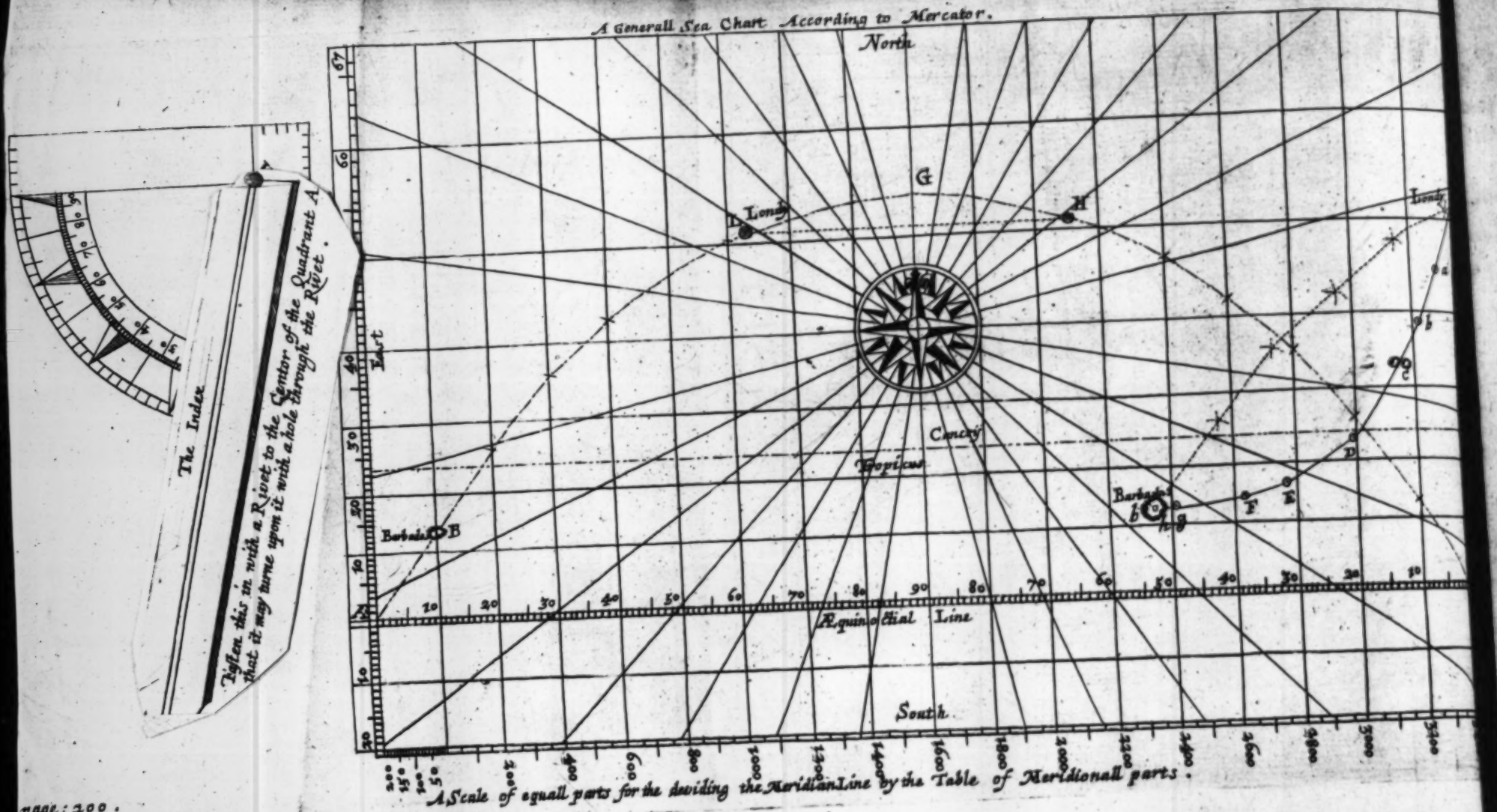
The *Protracting Quadrant* (you may ſee the *Figure* following) ſhews you all at one ſight, without more words, how to make it by dividing it into eight *Points*, and each *Point* into four *Quarters*, and an *Arch* within into 90 *deg.* and a *Libal* or *Index* to be rivetted to the *Center*, and a *Hole* drilled through the *Rivet*, to put a *Pin* through the *Center* of the *Quadrant* upon any Place aſſigned, and let him ſquare by the *Parallel-Meridians* and *Parallels* of *Latitude*; ſo laying the *Index* over the ſecond Place, the *Limb* of the *Quadrant* will ſhew you the *Point* of the *Compaſs*, and what *Angle* it makes with the *Meridian*, or bearing of the firſt Place from the ſecond, as we have ſhewn by divers *Arithmetical Rules*, for your more certain and exact direction, how to keep your *Reckoning* upon your *Mercator's Chart*, or *Blank*; and to know firſt and afterwards what *Rhomb* you are to ſail upon, keeping in or neer the *Arch* of a *Great Circle*; and to know what *Longitude* and *Latitude* you are in, after ſome progreſs made in your *Voyage*.

You ſhall have here alſo the way how you ſhall trace out the *Arch* of a *Great Circle* betwixt the Places in a *Blank* or *Mercator's Plat*, and how to prick down upon your *Chart* any *Diſtances* of *Longitude* and *Latitude*.

Before in the third *Rule* of *Chap.* 13. you have the way how to calculate for any *Degree* and *Minute* of *Obliquity*, and any number of *Degrees* of *Longitude*; what *Degrees* and *Minutes* of *Latitude* the *Great Circle* ſhall paſs through, by the ſame *Rules* I have calculated, for every 10 *Degrees* of *Longitude*, reckoning from the greateſt

Obliquity,




A Generall Sea Chart According to Mercator.
North
East
South
Aequinoctial Line
Cancri
Tropicus
Barbados
B
G
H
Lizard
Lizard
The Index
Tiglen this in with a Rivet to the Center of the Quadrant A that it may turne upon it with a hole through the Rivet.
A Scale of equall parts for the devideing the Meridian Line by the Table of Meridionall parts.

page: 200.

Obliquity, to the *Interſection* of the *Great Circle* with the *Æquator*, *viz.*

Greateſt Obliquity G 54 *deg.* 40 *min.*

For *Deg. Lat.*	10	20	30	40	50
	54 d. 15 m.	52:58	50:41	47:13	42:12

60	70	80:27	For	90 *deg. Longit.*
35:12	25:46	13:10		00 *deg. Latitude.*

In this following *Mercator's Plat*, G ſtandeth at 54 *deg.* 40 *min.* of *North Latitude*, and Æ juſt 90 *deg.* of *Longitude Weſtward*, and Æ N 90 *deg. Eaſtward* from G, being the two oppoſite *Points* in the *Æquator*, 180 *deg.* from each *Point* of *Interſection* Æ Æ.

In every *Meridian* betwixt G and Æ, on both ſides a *Meridian* drawn at every 10 *deg.* of *Longitude* in the *Chart*, make a mark at *Latitude* found in the *Table*, by the *Meridian-line* of the *Chart*; and having ſo marked every *Meridian* betwixt G and Æ, then by theſe marks ye may draw *Arches* from one to another: but it will ſuffice to draw *Right Lines* from Mark to Mark, as from G the greateſt *Obliquity* of the *Great Circle*, to the next *Meridian* on each ſide, and likewiſe to the next, until you come down to the *Æquator* at Æ on both ſides; ſo have you pourtrayed on this *Mercator Plat* a *Great Circle Arch* from *Lundy* to *Barbadoes*, one being in *North Latitude* 51 *deg.* 22 *min.* at L, the other at B in *North Latitude* 13 *deg.* 10 *min.* with *Difference* of *Longitude* 52 *deg.* 55 *min.* from C unto L, to C under B.

Note, To make a perfect *Circle*: the *Latitudes* of the *Arch* are the ſame on the *South* ſide of the *Æquator*, as you have found them on the *North* ſide. You might have marked out only ſo much of the *Great Circle* from the firſt *Latitude*, as you ſee I have done from the ſide of the *Meridian-line*, and *Latitude* of *Lundy* 51 *deg.* 22 *min.* at l, to *Latitude* 13 *deg.* 10 *min.* at B, by the *Difference* of *Longitude* in the laſt *Column* of the *Table* in *Chap.* 13. and *Difference* you will find of *Longitude* is 52 *deg.* 55 *min.* by the former Direction: The *Figure* makes all plain in the *Chart* or *Blank*.

Two Places in one *Latitude*, as in the ſecond *Situation Latitude* 51 *deg.* 22 *min.* as in the following *Chart*, one at H, and the other Place at L in the ſame *Latitude*, and *Difference* of *Longitude* 52 *deg.* 55 *min.* the neereſt Diſtance is not upon a *Parallel* directly from H to L, but from H to ſail from 51 *deg.* 22 *min.* by G the greateſt *Obliquity*, in *Latitude* 54 *deg.* 40 *min.* *W. N. W.* almoſt, then *W. b. N.* and *W. b. S: W. S. W.* the other half from G to L, which is the neereſt *Diſtance* by 42 *Miles*; for the *Diſtance* by the *Parallel* is 660 *Leagues*, but by the *Arch* of a *Great Circle* is but 646 *Leagues*: And one would not think but the *Parallel* were the neereſt, to look in the *Plat*: but he that knows the *Globe*, conceives that by the *Arch* that goes neerer the *Poles*, croſs the *Meridians*, to be the neerer; therefore the *Arch* muſt be the neereſt way. And ſailing into ſeveral *Latitudes*, you have the benefit to correct your *Dead Reckoning*, which you cannot ſo well do by keeping a *Parallel* of *Eaſt* and *Weſt*. Theſe Directions may be ſufficient for any Queſtions you will have any way in *Great Circle Sailing*.

But he that will take the pains, may find great delight in this ſort of Practice: Yet I muſt conclude, That although it is the neereſt way, it is not the conveniencteſt way for *Seamen*, for ſeveral Reaſons beſt known to them that keep an *Account* of the *Ships way*, which I could lay down here; but in regard it is needleſs, I leave every one to his mind, and ſhall ſhew you the way how I did keep my *Account* at *Sea*, by the *Plain Chart* and *Mercator's Chart*; and how to meaſure *Diſtances* in *Mercator's Chart*, in any *Parallel* alſo: which, if you have a better way, publiſh it, that others may gain benefit by it; for you will not hurt me any way; but rather I deſire, that all the *Navigators* in *England* did exceed me (for His Majeſtie's ſake, whoſe Subjects we are) and hope that the Neighbour-Nations will once know, That the *Engliſh Mariners* are not leſs known in *Art*, than by their *Courage*, which the *Dutch* know by dear-bought Experience.

Chap. XVII.

How to keep a Sea-Journal, *that ſo every* Sea-man, Navigator, *and* Mariner, *may not be aſhamed to ſhew their* Account *to any* Artiſt, *and by it benefit themſelves and others.*

I Would not have any ingenious *Sea-Artiſt*, that hath a long time kept Account of a *Ship's way*, and hath been *Commander* or *Mate* many years, to think I preſcribe him *Rules*, and to perſwade him out of his beaten Path (No, I think that a hard matter.) But we preſcribe *Rules* for thoſe that are but new Learners, that ſo they may have a perfect Method and Way of keeping Account of a *Ships way* at *Sea*; that if the *Maſter* ſhould perceive an Ingenious *Practicioner* aboard, and by examining his *Journal* find him able, might at his return home give him encouragement, by ſpeaking in his behalf to other Men to make him a *Mate*; and that is the way to encourage *Artiſts*: But I confeſs the greateſt Dunces have commonly the beſt Imployments, and many abler men before the *Maſt*: which is great pity, that the deſerving Men had not their right. But what ſhall I ſay? There is ſuch an averſment in Fate. Therefore I ſhall proceed to our *Journal*. I conceive it will be fit to have a *Book* in *Folio*, that a ſheet of *Paper* makes but two Leafs, and to keep the left ſide of your *Book* void, that you may write all the *Paſſages* of the *Voyage*; that is to ſay, when you ſet Sail, with what *Wind*, and what *Ships* are in company with you, and how far you keep company; what *Storms*, and how the *Wind* was: and likewiſe put down the time that you come by any misfortune, of cracking or breaking a *Maſt* or *Yard*, or if any Men ſhould die; and alſo what Damage you receive by any *Storm*, and the like Occurrences, as you ſhall think requiſite; and what *Currents* and *Variation* you meet with. But before all this, put down the Title of the *Voyage*, over the left-hand *Page*, in theſe or ſuch like Words, *viz.*

A Journal *of our Intended* Voyage *by God's Aſſiſtance from* Kingrode-Port Briſtol *in* Latitude 51 deg. 30 min. *to the* Iſland *of* Madara *in* Latitude 32 deg. 10 min. *and from thence to* Barbadoes *in* Latitude 13 deg. 10 min.

The right ſide of your *Book* throughout may be divided into 13 *Columns*, by *Lines*, as you may ſee in the following *Example*.

In the firſt muſt be expreſſed the day of the *Month*, in the ſecond the *Letter* of the *Week-day* that *Year*; put it once in the top of the *Page*: In the third *Column* the *Months*; make him large enough to put down the *Latitudes* you make by Obſervation of the *Sun* or *Stars*, and *Currents*, and how they ſet: In the fourth, the *Courſe* ſteered by the *Compaſs*: In the fifth, the *Variation* of the *Compaſs*, if there be any; or elſe the *Variation* by *Currents*, if there be any. Set down the *Angle* of the *Rhomb*, it made with the *Meridian* in the ſixth *Column*; and in the ſeventh, the *Diſtance* ſailed in *Leagues* or *Miles*: In the eighth, ninth, tenth, and eleventh *Columns*, ſet down the *Northing*, *Southing*, *Eaſting*, and *Weſting*: In the twelfth, the *Latitude* by *Dead Reckoning*; and in the thirteenth *Column*, the *Difference* of *Longitude* from the firſt *Meridian*, according to *Mercator's Chart*, or the *Arch* of a *Great Circle*, or a *Polar Chart* or *Globe*.

The

A Journal of our Intended Voyage, by God's Assistance, in the Good Ship the Elias, of [illegible] Commander, from King[illegible] in Latitude 51 d. 30 m. to Madeira in Latitude 32 d. 30 m. and from thence to Barbadoes, Latitude 13 d. 10 m.

See Fail [illegible] Company with the Ship bound to Cales, and [illegible] bound [illegible] the Wind at N. E. this Day Weather.

1666. Month Days.	Week Days.	A Journal of our Intended Voyage, by God's Aſsiſtance, in the Good Ship the Eliz. of B. S. S. Commander, from Kingrode in Latitude 51 d. 30 m. to Madara in Latitude 32 d. 30 m. and from thence to Barbadoes, in Latitude 13 d. 10 m.
March 25	S	Set ſail out of *Kingroad*, in Company with the *John* bound to *Cales*, and *Ann* bound to *Virginia*; the Wind at *E. N. E.* thick rainy Weather.

The Journal of our Intended Voyage, by God's Assistance, in the *C.* (of *B.*) *S. S.* Commander, from *Lundy*, in Latitude 51 *d.* 20 *m.* to the Island of *Madara*, in Latitude 32 *d.* 30 *m.* Angle of Position, or Course S. S. W. 1 *d.* W. Distance 411 Leagues, Meridian Distance 167 Leagues, Difference of Longitude 11 *d.* 16 *m.* from *Madara* to *Barbadoes*, in Latitude 13 *d.* 10 *m.* Angle of Position or Course S. W. 61 *d.* 14 *m.* Distance 798 Leagues, Meridian Distance 698 Leagues, Difference of Longitude 41 *d.* 40 *m.*

		51 deg. 20 min.	Course	5 East	Degr. from the	Distan.	Diff. La	Diff. La.	M. dep.	M. dep.	51 d. 20′	diff. Lo.
		32 deg. 30 min.	S S W	Variation.	Merid. SW 2 5d.	411	377	377	167	167	32 d. 30′	11d. 16′
		13 deg. 10 min.	SWbW half W		S W 61 d. 14 m.	798	387 lea.	387 lea.	698	698	13 d. 10′	41d. 40
		Latitude by Observation.	Course by Compass.	Variation of Compass.	Degrees from the Meridian.	Dist. sailed.	North.	South.	East.	West.	Lat. by dead R.	Diff. of Longit.
		Degr. Min.	Points.	Degrees.	Degrees.	Leag. 10	Lea. 100	Lea. 100	Lea. 100	Lea. 100	D. M.	D. M.
26	a	Set sail March 25.	S b W half W	5 deg 30 min. E	S W 22 d. 30 m.	48		44 35		18 37	49 07	
27	b		S b W half W	5 deg. 30 min. E	S W 22 d. 30 m.	49		45 27		18 75	46 51	
28	c	44 deg. 31 min.	S b W half W	5 deg. 30 min. E	S W 22 d. 30 m.	51		47 12		19 52	44 30	
29			Add up the Numbers, the sum is			148		136 74		56 64		04 14
30	d		S S W	2 deg. 45 min. E	S W 25 d. 15 m.	43		38 87		18 38	42 34	
31	e	40 deg. 27 min.	S S W	1 degree East	S W 22 d. 30 m	46		42 50		17 60	40 26	
32	f	38 deg. 30 min.	S S W	0 degr. East	S W 22 d. 30 m.	39		36 03		14 92	38 38	
			Add up the Numbers, the sum is			128		117 40		50 90		
			Correction by Observation			2 9		2 70		01 10	8	
			The sum corrected is			130 9		120 10		52 00	38 30	07 43
			Difference of Latitude, Depart. from first Merid.			278		256 84		108 64		
1	g	April 3 a Current	S W b S	11 d. 30 m. Cur.	S W 22 d. 30 m.	43		43 42		17 99	36 17	
2	a	sets E b S.	S W b S	11 d. 30 m. Cur.	S W 22 d. 30 m.	45		41 57		17 22	34 12	
3	b	32 deg. 30 min.	S W b S	11 d. 30 m. Cur	S W 22 d. 30 m.	42		38 80		16 07	22 19	
		Set to th'Eastward	Add up the Numbers, the sum is			134		123 79		51 28		
		by the Current in	Correction by Observation			3 9	3 66		1 50		11	
		3 days 22 Leagues	The sum corrected is			131		120 13		49 78	32 30	10 46
4	c	and almost a half	Madara Island bears West distant			8.58				8 58		
		E b S by estimat.	Difference of Latitude, Depart. from first Merid.			418		376 97		167 00	32 30	11 16
24	d	Set sail April 23.	S W b S	5 d. 30 m. East	S W 28 d. 30 m.	36		31 75		16 97	30 55	
		from Madara.		by Current.								
25	e		S W b S	2 d. 45 m. East	S W 30 d. 45 m	46		39 46		23 65	28 57	
26	f	27 deg. 43 min.	S W b S		S W 33 d. 45 m.	30		24 94		16 67	27 42	
27	g	25 deg. 54 min.	S W		S W 45 degr.	51		36 06		36 06	25 55	
28	f	23 deg. 47 min.	S W		S W 45 degr.	60		42 43		42 43	23 48	
29	g	22 deg. 40 min.	S W		S W 45 degr.	28		19 80		19 80	22 47	
			Numbers added, the sum is			151		194 44		155 58		
			Correction by Observation			3		2 30		1 90	7	
			Sum corrected is			154		196 74		157 48	22 40	
29			Difference of Latitude, Depart. from first Merid.			572		573 72		324 48		20 47
30	a		S W b W	00 degr.	S W 56 d. 15 m.	45		25 00		37 42	21 25	
1	b	May	S W b W	00 degr.	S W 56 d. 15 m.	47		26 11		39 08	20 07	
2	c	18 deg. 57 min.	S W b W	00 degr.	S W 56 d. 15 m.	43		23 89		35 75	18 56	
3	d		S W b W	00 degr.	S W 56 d. 15 m.	44		24 44		36 58	17 43	
4	e	16 deg. 50 min.	S W b W	00 degr.	S W 56 d. 15 m.	39		21 67		32 43	16 37	
			Add up the Numbers, the sum is			218		121 11		181 26		
			Correction by Observation			7 8	4 33		6 50		13	
			Sum corrected is			210 2		116 78		174 76	16 50	
4			Difference of Latitude, Depart. from first Merid.			782 2		690 49		499 24		31 06
5	f	16 deg. 14 min.	W S W half W	5 degr. West	S W 67 d. 30 m.	31		11 86		26 64	16 15	
6	g	14 deg. 03 min.	W S W half W	5 d. 30 m. West	S W 67 d. 30 m.	46		17 60		42 50	15 22	
7	a		W S W half W	5 d. 30 m. West	S W 67 d. 30 m.	33		12 63		30 49	14 44	
8	b	14 deg. 03 min.	W S W half W	5 d. 30 m. West	S W 67 d. 30 m.	30		11 48		27 72	14 09	
			Add up the Numbers, the sum is			140		53 57		127 35		
			Correction by Observation			5 2		2 00		4 80	6	
			Sum corrected is			145 2		55 57		132 15	14 03	
8			Difference of Latitude, Depart. from first Merid.			927 4		746 6		631 39		38 50
9	c	13 deg. 48 min.	W b S half W	5 degr. half	S W 84 d. 20m.	55		5 39		54 73	13 47	
10	b		W b S half W	2 degr. 50 min.	S W 87 d. 11 m.	60		2 94		59 91	13 39	
11	e	13 deg. 10 min.	W b S half W	00 deg. 00 min.	S W 78 d. 30 m.	51		9 95		50 02	13 09	
		Ship is in Lat. Bar-	Add up the Numbers, the sum is			166		18 28		164 67		
11		badoes 69 lea. Ea.	Difference of Latitude, Depart. from first Merid.			1092		764 34		796 06		48 41
12	g	13 deg. 00 min.	West	5 d. 30′ Cur. sets	S W 84 d. 22 m.	39		3 80		38 60	12 59	
12		The Current set S.	W b N	S. 2 d. 45′ Cur.	S W 81 d. 30 m.	26	81			25 71	13 10	
13	g	13 deg. 11 min.	Difference of Latitude, Depart. from Lundy			1163		764 33		860 37	13 10	52 39
13		Barbadoes Island bears West distant of Leag.				5						

Let this be our Example.

We will frame a *Reckoning* between the three Places before-mentioned, from *Lundy* to *Madera*, from thence to *Barbadoes*, whose *Distance* in their *Rhombs*, and *Difference* of *Latitude*, and *Meridian-distance*, I have put over in the head of the left-hand *page*, as you may see, answers to the words under. And in truth, I have found these *Distances* very near the truth; In two *Voyages* I differ but two *Leagues*, and that I was short. I worked it first out of a *Mercator-Chart*, and in *Plain Sailing* took the Product of that Work for my *Distance*, and *Meridian-distance*, and *Course*, as you have been already shewn in the first Question in *Mercator-Sailing*.

You see by the left-hand *Page* that we set sail the 25th day; but we entred it not in the right-hand *Page* until the 26th day at Noon: for it is to be understood, That since her setting sail *March* 25. to Noon of the 26th day, the *Ship* steers away and makes her Way good on the *S. b. W.* $\frac{1}{2}$ *W. Point* of the *Compass*; but the *Variation* being 5 *deg.* $\frac{1}{2}$ or half a *Point* to the *Eastward*, as you see in the fifth *Column*, therefore the *Point* she hath made good upon is only *S. W.* 22 *deg.* 30 *min.* as is expressed in the sixth *Column*: Upon this *Rhomb* she sails 48 *Leagues*, as in the seventh *Column* appears: And answerable thereunto I find in the *Traverse-Table* before-going, the *Southing* to be 44 $\frac{35}{100}$ *Leagues*, or by the *Traverse-Scale* 44 $\frac{4}{10}$ *Leagues*; and the *Westing* 18 $\frac{37}{100}$ *Leagues* by the *Traverse-Scale* 18 $\frac{4}{10}$ *Leagues*, as here in the ninth and eleventh *Column* appears by the Figures plainly set down. The *Figures* to the left hand signifie *Leagues* in this *Journal*, or *Miles*; and the two *Figures* to the right hand signifie the 100 part of a *League*: The *Southing* being 44 $\frac{35}{100}$ *Leagues*, which is 2 *deg.* 13 *min.* nearest; if that be substracted from the *Latitude* from whence you came, *Lundy* 51 *deg.* 20 *min.* it makes the *Latitude* the *Ship* is in at Noon to be 49 *deg.* 07 *min.* as appears in the twelfth *Column*. In the same manner, the second entrance, being the 27th of *March*, sheweth, that from the 26th day at Noon, to the 27th day at Noon, she made her way good upon the *S. b. W.* $\frac{1}{2}$ *W. Point* of the *Compass*; but the *Variation* being 5 *deg.* $\frac{1}{2}$ *Easterly*, therefore the *Angle* of the *Rhomb* which the true *Meridian* was from the *South* to the *Westward S. W.* 22 *deg.* 30 *min.* and sailing 49 *Leagues*, the *Southing* is 45 $\frac{27}{100}$ *Leagues*, and the *Westing* 18 $\frac{71}{100}$ *Leagues*: So the *Latitude* is now 46 *deg.* 51 *min.* So the third Entrance is the 28th day, the *Course* and *Variation* the same as before, and the *Distance* 51 *Leagues*; the *Southing* 47 $\frac{13}{100}$ *Leagues*, the *Westing* 19 $\frac{53}{100}$ *Leagues*: So the *Latitude* now is 44 *deg.* 30 *min.* You must understand the like manner of working of all the rest. What hath been said of a *Reckoning* may suffice; but it is of very good use to set down the *Longitude* in the last *Column*, and a *Rule* how to convert the *Easting* and *Westing*, that is, the *Leagues* or *Miles* in the *East* and *West Column*, into *Degrees* and *Minutes* of *Longitude*. I will give you this *General Rule*, that you may do it neer enough, without any sensible Error, on your *Mercator Chart*, or *Polar Chart* or *Globe*, provided these *Rhombs* differ not much one from another; by which *Rule* I found the *Longitude* for every *Sum* in the *Journal*. Say then,

Not that I do affirm the Variation to be Easterly for I know it to be 1 d. 30 m. *West*; *but being neer the truth or not, it serves to exemplifie the Rule, that being the end for which this Example is made.*

As the Difference *of* Latitude,
To the Departure *from the* Meridian:
So is the Difference *of* Latitude *in* Meridional parts,
To the Difference *of* Longitude *in* Leagues *or* Miles.

The *Difference* of *Latitude* in the *South Column* summ'd up (as you must do as often as you have any notable *Difference* betwixt your observed *Latitude* and *Dead Latitude*) is 136 $\frac{74}{100}$ *Leagues*; omit the last *Figure* to the right hand $\frac{4}{100}$, and then it will be 136 $\frac{7}{10}$.

The *Departure* from the *Meridian* in the *West Column* is 56. 64; omit the last *Figure*, it is 566: So you put them down.

But if you sail all on one Course, the Rule is in the third Probl. of Mercator Sailing.

The Meridional parts *for the* Latitude 51 deg. 22 min. *is* ——— 12002
The Meridional parts *for the* Latitude 44 deg. 30 min. *is* ——— 9959
The Difference *of* Latitude *in* Meridional parts *is* ——— 2043

Say then,

As the Sum *of the* South Column, *or* Difference *of* Latitude 1367—313576
Is to the Sum *of the* West, *or* Departure *from the* Meridian 566—275281
So is the Difference *of* Latitude *in* Meridional parts 2043——321026
606307
To the Difference *of* Longitude *in* Leagues $84\frac{8}{10}$——292731

As Radius 90 *deg. To* Tang. Rhomb: *So difference of* Lat. *in* Merid. parts, *To difference of Longitude in* Leagues *or Miles.*

Which reduced into *Degrees* is 4 *deg.* 14 *min.* for the 28th of *March.* So ſtill you muſt remember to take the *Sum* of *Difference* of *Latitude* and *Departure* from the firſt *Meridian.* There are ſeveral other *Rules* you may ſee laid down before, for a *Parallel-Courſe* of *Eaſt* and *Weſt*, and other *Rules* to find the *Longitude*; as occaſion requires, you may make uſe of them: But this *Rule* ſaves you trouble, and comes neer enough in ſailing ſeveral Courſes.

8 *min. is* $2\frac{7}{10}$ *Lea. neer*
1201 *to* 520
ſo 27:) 27
3640
1040
14040
203
14040 ($1\frac{1}{10}$
1201
120

But let us proceed with our *Journal.* I obſerved the *Meridian Altitude* of the *Sun* the third day at Noon, that is from 30 at Noon to 31. I find my *Latitude* by obſervation 38 *deg.* 30 *min.* which, by *Dead Reckoning* it, is but 38 *deg.* 38 *min.* ſo the *Difference* is 8 *min. Southerly*; but being aſſured of a good *Obſervation*, I correct the *Dead Reckoning* thereby, by this *Rule* of *Proportion*, ſaying,

As the Sum *of the* North Column *corrected is* 1201——307954
To the Sum *of the* Eaſt Column *corrected* 520——271680
So is the aforeſaid Increaſing Southerly 27——143136
414736
To the Increaſing Weſterly $1\frac{17}{100}$ *Leagues*——106782

Which is 1 *League* $\frac{1}{10}$, and ſomething more, not to be taken notice of. This *Rule* of *Proportion* Mr. *Norwood* hath laid down in *page* 111. of his *Seaman's Practice*, in the Deſcription of his *Journal* in *Miles*, from *Barwoodoes* or *Summer Iſlands* to the *Lizard*; which method I do in many things follow, but not all: But this *Rule* that I propoſe is by the *Traverſe-Scale*, which I hold beſt, which is thus.

By the Traverſe-Scale.

Extend the *Compaſſes* from the *Point* made good in the laſt ſumming up, to the number of *Leagues* or *Miles Difference* of *Latitude* by Obſervation, and by *Dead Reckoning*, in the *Line* of *Numbers*; the ſame *Diſtance* will reach from ſome *Points* from the *Eaſt* and *Weſt*, to the *Difference* of *Eaſt* or *Weſt*.

As for Example.

Extend the *Compaſſes* from 2 *Points* and a little more (which was the *Sum* of the *Courſe* made good the 31 of *March*) unto $2\frac{7}{10}$ *Leagues*, which is 8 *min.* or thereabouts in the *Line* of *Numbers*; the ſame Extent will reach from 6 *Points* to $1\frac{1}{10}$ *Leagues* and ſomething more in the *Line* of *Numbers*, and that is the increaſing *Weſterly*. You may alſo with the ſame Extent correct the *Diſtance*, if you put one Foot at W or 100 in the *Line* of *Numbers*, the other will reach to the *Diſtance* $2\frac{9}{10}$ *Leagues* corrected by Obſervation, as you ſee I have done in the *Journal*. So you ſee, That underſtanding perfectly the Uſe of the *Traverſe-Scale*, you may do the ſame, and more readily, as Mr. *Norwood* doth with his *Table*, to every *Degree* and *Minute* of the *Quadrant*, without ſenſible Error.

Now this *Difference* being found, I add therefore and put down in the *South Column* the *Difference* $2\frac{70}{100}$ *Leagues*, and the *Weſt Column* $1\frac{16}{100}$ *Leagues*, and under *Diſtance* $2\frac{9}{10}$ *Leagues*: Now the ſame corrected is by obſervation $130\frac{9}{10}$ *Leagues*, *Diſtance* $120\frac{10}{100}$ *Leag. Southing* and *Weſting* 52 *Leag.* 8 *min.* ſubſtracted from the *Dead Latitude*, make 38 *deg.* 30 *min.* the true corrected *Latitude* according to obſerva-

tion:

tion: Then I ſum up the firſt *Sums* of the 28 of *March*, and this *Sum* corrected 31 of *March* together, and you have the *Diſtance* 278 *Leagues*, *Difference* of *Latitude* 256 $\frac{84}{100}$ *Leagues*, and *Departure* 108 $\frac{64}{100}$ *Leagues*, and by the Rules before-given 256 $\frac{8}{10}$ *Leagues Southing*, and 108 $\frac{6}{10}$ *Leagues Weſting*; and with the *Difference* in *Meridional Leagues* 364 $\frac{7}{10}$ *Leag.* I find the *Difference* of *Longitude* in *Leagues* 154 $\frac{7}{10}$ *Leagues*, converted into *deg.* and *min.* is 7 *deg.* 43 *min.*

This is becauſe I find my ſelf to the Northward, that is, leſs to the Southward by 11 *m. than by Dead Reckoning, & therefore leſs to the Weſtward* 1 $\frac{50}{100}$ *Leag. or ſo much to the Eaſtward, by reaſon my Courſe is in the S. W. Quarter, it muſt be corrected in the contrary Quarter.*

In like manner, upon the third of *April* I ſhould be in *Latitude* 32 *deg.* 19 *min.* but by very good obſervation, I find the *Ship* in the *Latitude* 32 *deg.* 30 *min.* that is, not ſo much *Southerly* by 11 *minutes*: therefore to correct it by Obſervation, I put under *Diſtance* 3 $\frac{9}{10}$ *Leagues*, and in the *South Column* 3 $\frac{66}{100}$ *Leagues*, and in the *Eaſt* 1 $\frac{50}{100}$ *Leagues*, and under *Dead Latitude* 11 *min.* I ſubſtract the corrected *Difference* of *Diſtance* out of the *Sum* over it, and likewiſe the corrected *Difference* in the *North Column* out of the *Sum* in the *South*, and likewiſe the *Eaſt* out of the *Weſt Column*, and add the 11 *min.* to the *Dead Latitude*, and then you have the *Sums* corrected; but if there be any *Current*, you may ſet it down, and allow for it, and note it down, as is that *Example* following the firſt of *April* to the third, and by your *Traverſe-Scale* preſently find how much the *Current* hath ſet you to the *Eaſtward*.

In ſailing Eaſt and Weſt, you have a Rule in Probl. 7. *of ſailing by* Mercator *or Mr.* Wright's *Chart.*

But if your *Courſe* be neer the *Eaſt* and *Weſt*, it is ſufficient to correct it in *Latitude* only, as in the *Example* of the 12th and 13th of *May*; for in that Caſe the *Longitude* cannot be corrected but from ſome further ground. Now to ſet down this *Reckoning* upon the *Plain Chart*, or common *Sea-Chart*, it is needleſs and unneceſſary: The better way is to ſet down every one of the *Sums* as they are corrected by Obſervation, in the ſame manner as you are directed in the latter end of the third *Chapter* of this *Book*; and ſo by the total *Sums* of the *Difference* of *Latitude* and *Departure* from the firſt *Meridian*, or *Latitude* and *Meridian-diſtance*, you may ſet it down on your *Draught* or *Chart* as often as you pleaſe with eaſe.

Now to ſet off every *Sum* corrected in *Degrees* of *Latitude* and *Leagues* of *Longitude*, you have a *Scale* of *Leagues* or *Miles* for that very purpoſe, and *Directions* how to do it, in the ninth *Chapter* of this *Book*: But if you are deſirous to ſet down your *Reckoning* in a *Mercator* or Mr. *Wright's Chart*, or in the *Polar Chart*, you have in the 12th and 13th, or laſt two *Columns* of your *Journal*, the ſubſtance and principal ſcope of your *Reckoning* ſet down as often as you ſum up or correct your *Reckoning*: namely, your *Latitude* and *Longitude*; which whenſoever you have a deſire to ſet down in the foreſaid *Chart*, or any other graduated *Chart*, with *Degrees* of *Longitude* and *Latitude*, you may readily do it.

As for Example. Suppoſe I would ſet down the *Plat* of the aforeſaid *Journal* from the 25th of *March* to the 13th of *May*, I find the *Latitude* againſt the 25th of *March* 51 *deg.* 20 *min.* and the *Latitude* of the *Barbadoes* 13 *deg.* 10 *min.* and the *Difference* of *Longitude* 52 *deg.* 35 *min.* Therefore in the *Latitude* of 13 *deg.* 10 *min.* I draw or point out an occult *Parallel*, and reckon 52 *deg.* 35 *min.* from the *Iſland Lundy* towards the *Weſt*: I draw by that *Longitude* an occult *Meridian*; the *Interſection* of this *Meridian* with the foreſaid *Parallel* is the *Point* repreſenting *Barbadoes*, or the Place of the *Ship*; and the like is to be underſtood of any of the other: And ſo I put down in the *General Chart* of *Mercator* the 8 *Points* of the *Ship's* Place, 1 a, 2 b, 3 c, 4 d, 5 e, 6 f, 7 g, 8 h, as there you may ſee. This form of keeping a *Reckoning* is the moſt fit and agreeable of all others as I have ſeen or heard of, to all ſorts of *Charts*, *Maps*, or the *Globe* it ſelf, and to all kinds and ways of Sailing whatſoever.

I hope this way will find good acceptation with the ingenious Mariner or Artiſt.

Chap. XVIII.

A Deſcription of the following Table *of the* Latitude *and* Longitude *of Places, and the way how to find both.*

THE ancient *Geographers*, from *Ptolomy's* time downward, reckoned the *Longitude* of Places from the *Meridian*, which paſſeth through the *Cabo Verde Iſlands*; and others have the beginning at the *Canary Iſlands*; and *Jodocus Hondius* beginneth at the *Iſle Pico* one of the *Azores*; and Mr. *Emery Mullinenx* doth account the *Longitude* from the *Weſtermoſt* parts of St. *Michael's*, another *Iſland* of the *Azores*: who, albeit they differ greatly in reſpect of the beginning of each of their ſeveral *Longitudes*, they come all to a neer agreement for their *Difference* of *Longitude* from any particular *Meridian* or Place: And for the exact ſetling of *Latitudes*, we have many certain helps; but the *Longitude* of *Meridians* hath ſtill wearied the moſt able Maſters of *Geography*. By *Latitude* and *Longitude* the *Geogrnphers* ſtrive to repreſent the Parts of the Earth, that they may keep Symmetry and Harmony with the Whole.

Now the *Longitude* of any Place is defined to be an *Arch* or *Portion* of the *Æquinoctial*, intercepted between the *Meridian* of any Place aſſigned; as the *Meridian* that paſſeth through the *Lizard*, the moſt *Southern* Land of *England*, or any other Place from whence the *Longitude* of Places is wont to be determined. Many have endeavoured to ſet down divers ways how to find by obſervation the *Difference* of *Longitude* of Places; but the moſt certain way of all for this purpoſe, is confeſſed by all Learned Writers to be by the *Eclipſes* of the *Moon*: But now theſe *Eclipſes* happen but ſeldom, and are yet more ſeldom and in very few places obſerved by the skilful Artiſt in this *Science*; ſo that (ſome there are) but very few *Longitudes* of Places deſigned out by theſe means.

If you would know how to find out the *Longitude* of any Place by the *Eclipſe* of the *Moon*, you muſt firſt get ſome *Ephemerides*, as the *Practick Tables*, or Mr. *Vincent Wing's Directions* in his *Harmonicon Cœleſte*, *pag.* 150. or any other Learned *Mathematicians* Calculation, and ſee what hour ſuch an *Eclipſe* of the *Moon* ſhall happen at that Place for which the ſaid *Tables* were made; then afterwards you muſt obſerve the ſame *Eclipſe* in that Place whoſe *Longitude* you deſire to know. Now if the time of the *Eclipſe* agree with that other for which the *Tables* were made, then you may conclude, that both Places have the ſame *Longitude*, and are ſcituated under the ſame *Meridian*. But if the number of the *Hours* be more than the Place you are in is ſcituate *Eaſtward*, you muſt therefore ſubſtract the leſs *Number* out of the greater, and the Remainer muſt be converted into *Degrees* and *Minutes*.

A TABLE

A TABLE OF THE *LONGITUDE* and *LATITUDE* Of the moſt Notable Places,

That is,

HARBOURS, HEAD-LANDS, and ISLANDS OF THE

WORLD.

Newly Corrected, and Compoſed after a new manner, by beginning the ſaid *Longitude* at the *Meridian* of the moſt *Southern* Port of *England*, the *Lizard*.

By Capt. SAMUEL STURMY *Math.*

The Sea-Coaſt of Newfound-Land, *and* New-England.

The Places Names.	*North Latitude* D.	M.	*Weſt Longit.* D.	M.
Cape Honblanto	52	11	50	14
Belile	51	02	48	44
Cape Bonaviſta	49	19	47	42
Trinity *Bay*	48	54	49	04
Bacalao *Iſland*	48	40	46	55
Conſumption *Bay*	48	21	47	49
Cape St. Francis	48	01	47	27
Cape Daſpaire	47	36	46	03
Cape de Raca	46	27	46	30
Bay Bulls	47	28	47	11
St. John's *Harbour*	47	47	47	21
Plaſantia *Bay*	47	32	47	41
Cape St. Larinſo	47	10	48	59
Iſland St. Paly	47	36	50	18
Cape Raya	48	05	52	49
Cape Deganica	54	01	53	21
New-Eng. *Cape S.* Charles	52	48	52	23
Cape Brittan	46	01	52	57
Cape Salila	43	46	55	22
Cape Codde	42	21	61	32
Boſton	42	39	64	36
Plymouth	42	07	62	35
Nantucket	41	08	60	17
Martins Tinyard	41	17	61	12

The Sea-Coaſts on the main Continent in America, *or* Weſt-India.

The Places Names.	*Latitud.* D.	M.	*Longit.* D.	M.
Elizabeth *Iſland*	41	02	62	04

Bloik-

The Places Names.	*North Latitud.* D.	M.	*West Longit.* D.	M.
Bloik Iſland	40	55	62	36
Long Iſland	40	45	63	16
Cape May	39	55	64	45
Virginia. Cape Charles	37	47	65	26
Cape Henry	37	01	65	38
Cape Hatcraſs	35	49	65	46
Cape Fara	34	06	69	56
Cape de Catocha	21	23	80	37
Cape de Camaron	16	05	76	19
Cape de Gratias	15	31	70	56
Cattergaine	10	24	65	06
Bay Tonto	12	10	62	36
Cape *St.* Roman	11	55	60	36
Cape Dacodara	11	08	56	38
Cape Trag, *or* 3 *Points*	11	17	55	41
Cape Brama	09	21	54	16
Cape Dasbaſſas	08	20	53	11
Suramo	06	09	50	56
Suranam	05	58	49	52

The Weſt-India Iſlands.

The Places Names.	*North Latitud.* D.	M.	*West Longit.* D.	M.
Defonſſeaca Iſland	12	23	48	36
La Burmuda	32	25	56	00
Behama	27	57	73	06
Teavis	27	27	71	04
Sigvatro	26	18	68	45
Guatro	25	47	68	00
Guamina	25	15	67	53
Tiango	24	33	66	30
Guanahimo	23	50	66	39
Mayagnana	23	05	66	51
Caycoſs	22	05	64	31
Amiana	21	40	64	38
Inagua	21	19	67	03
Yamatta	22	32	67	49
Soamia	24	20	68	50
Javaqua	25	10	71	30
Yamia	24	22	70	10
St. John	18	30	60	42
Santa Cruce	17	42	59	18
Anguilla	18	48	57	00
St. Martin	18	35	56	47
St. Bartolama	18	15	56	33
Barbada	17	18	55	39
Antego	16	32	54	52
Daſſijada	16	00	54	36
Marigallatita	15	41	55	26
Dominica	15	00	55	05
Mattalina	14	20	54	44
St. Lucia	13	30	54	43

The Places Names.	*North Latitud.* D.	M.	*West Longit.* D.	M.
Barbadus	13	10	52	58
Tobago	11	12	53	06
Point Degallaia	10	45	53	31
Gianada	12	10	54	32
St. Vincent	12	50	54	28
Guardadupa	16	00	55	31
Monſariat	16	20	55	41
Mayes	17	00	56	27
St. Criſtova	17	30	56	45
Iſland Devas	15	57	57	28
Iſland Blanco	12	20	56	52
Margaita	11	28	56	37
Turtuga	11	30	57	40
Iſland Derickilla	12	19	58	01
Boca	12	19	58	53
Iſland Deavos	12	29	59	22
Bonoga	12	32	60	54
Quiſſa	12	25	60	39
Moagos	12	20	61	55
East end of Hiſpaniola	18	47	62	28
Middle of Hiſpaniola	18	30	64	58
Weſt end of Hiſpaniola	18	25	68	26
East end of Jamaica	18	00	71	58
Jamaica *Harbour*	18	15	72	57
Weſt end of Jamaica	18	38	74	57
The East end of Cuba	22	00	75	56
Caimanis	19	42	77	41
Grand Caiman	19	21	78	45
Santavilla	17	28	77	50
Moſquito	14	50	76	04
Guanabo	16	33	81	19
Guanabimo	16	10	83	04
Cozumal	19	25	84	56
Laſalleerauas	22	00	87	58
The Iſland Delas	23	30	91	58
Abraio	25	50	94	00
Labarmaia	22	55	93	16
Iſland Dearanas	22	36	93	14
Triango	21	23	93	05
Zarka	20	50	93	00
The Iſland of Proudanco	13	27	81	16
St. Andrea	12	42	80	57

The Sea-coaſts of Brazilia.

The Places Names.	*South Latitud.* D.	M.	*West Longit.* D.	M.
The River Amazones	00	00	41	30
The Iſland *of St.* Paul	00	55	14	36
The Iſland *of* Aſcenſion	07	48	20	06
Cape Blanco	02	25	22	29
Iſland Rocas	03	42	17	16
Iſland Farnando	03	40	15	16

Abratho

The Places Names.	*South Latitud.* D.	M.	*West Longit.* D.	M.
Abratho	05	00	17	56
Cape St. Raphall	06	10	19	36
Cape St. Auguſtin	08	25	18	28
River St. Mignall	09	30	19	01
The River Roall	11	21	20	41
River Gianda	14	49	22	06
Cape de Abeotho	17	52	21	42
St. Harbara	18	11	21	06
Iſland Aſcenſion	17	19	17	01
Trinidada	19	50	14	24
St. Maria Dagaſta	19	38	12	14
Iſland de Martin	19	00	08	03
Iſland de Pidos	21	52	05	51
Cape St. Toma	21	47	23	38
Cape Frio	22	52	24	43
Cape St. Maria	35	00	37	11
River de Platta	35	50	45	52
Port St. Juliano	50	00	52	30
The Streights *of* Magellane	53	30	56	30
Cape de Sancto Spirito	52	20	58	30
Cape Victoria, *Weſt end of the* Streights	52	30	65	40
Lima Cape	12	00	80	30
Cape Guya, Cape Blanco	06	10	85	30
Cape St. Frainſco	01	30	80	30
Cape St. Frances	*North.*		*Weſt*	
Point de bon matre	07	30	80	00
Nombre de Dios. *W. Sea*	10	00	77	30
Nova Albion, *or* New-England, *in the South Sea, the back ſide of it*	46	00	162	30
Cape de Fortuna (Aniar. fra.	55	30	170 *E.*	00
Inſulæ Salamonis	*So. Lat.*		*W. Long.*	
Nombre de Jeſus	05	50	169	30
Tapan Inſule	36 *N.*	00	153 *E.*	00
Cape de Buena Deſco	01 *S.*	00	155	00

The East India *Iſlands.*

The Places Names.	*South Latitud.* D.	M.	*East Longit.* D.	M.
Hipon Iſland	06	45	125	20
Bantam, East-India	06	15	115	34
Jamba Iſlands	01	49	122	25
South end of Sumatra	05	52	125	48
Middle end of Sumatra	01	30	120	49

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
North end of Sumatra	05	28	116	35
Gomaſpala	05	40	116	29
Niobar	07	00	115	04
Iſland Deſombro	08	00	114	44
Iſland Ruſta	09	50	114	33
Quarinibar	11	10	114	44
Chitra Andomaio	12	00	114	41
Iſland Dandemajo	13	00	114	39
Iſland Decocoſs	14	30	115	12
Celloan	07	50	98	39
Doda Safia	09	40	93	02
Andaio	11	30	90	51
Garine	10	50	90	56
Moique	09	05	91	29
Cuballa	08	53	91	07
Iſland de Proſoll	10	23	90	55
Iſland de Zocha	11	12	90	45
Chorebaman	12	32	87	55
Sucatra	12	18	74	01
Abdelcari	12	12	71	44
Apoluria	09 *S.*	20	90	50
Adu	05	39	88	50
Degomo	02	40	87	35
Piedros Blanco	06	10	76	55
Diego gratioſa	08	30	78	15
Set Hermanas	03	02	70	25
Domes Caicuhas	03	21	65	24
Iſland Quellalfo	03	40	64	20
De Almiranta	03	57	63	28
Agnalaga	09	00	66	15
Aſdore Has	09	05	65	02
John de Nava	09	00	63	26
Coſmobodo	09	40	61	52
Donatall	08	20	59	57
Aignos	09	30	58	18
John de Comoro	09	00	57	20
Pemba	05	09	53	30
Zanziba	06	26	53	35
Manfia	07	50	53	08
John Demiz	10	48	54	24
Comoro	11	20	55	48
Mohalla	12	11	56	25
Foanna	12	09	57	03
Mayatra	12	40	57	55
St. Chriſtopher	14	30	56	03
John de Nova	17	20	55	29
Baſſas de India	22	10	55	22
North end of St. Laurente	25	37	60	54
St. Apohima	20	50	65	54
Domſcaicahas	20	50	66	54
Moroſlaſs	20	10	68	44
Doſgarias	15	20	70	43
St. Branda	17	13	74	44

The Places Names.	*South Latitud.* D.	M.	*East Longit.* D.	M.
Englands Foreſt	20	50	71	14
Diego Roize	20	05	74	54
John de Lisbone	25	24	68	32
Romoras	28	19	81	21

The Sea-coaſt on the Main Continent in the East India.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Malacca	01	41	116	14
Queda	06	47	117	44
River de Care	10	45	118	54
River Bongale	22	09	121	33
Aicopoir	20	19	112	39
Samnabron	18	30	108	52
Arme Gor	14	35	100	27
Naga Patam	11	21	99	59
Cape Comorin	07	50	97	39
Cochin	09	40	97	29
Callant	10	48	97	27
Mongalar	12	40	97	19
Dodall	17	01	98	55
Goa	14	40	97	01
Chaul	18	10	98	51
Calecut *in* East India	11	30	92	58
Macao *in the K. of* Pegu	19	30	112	49
Domon	19	54	99	01
Surrat	21	00	99	36
Dio	20	48	96	57
River Decinda	24	55	95	39
Gudar	24	50	89	28
Cape Muchoaridan	25	32	82	39
Cape Ruſſallgat	22	07	84	39
Cape de Ponto	18	19	79	09
Dofar	17	00	75	04
Cape de Matriaia	15	33	72	39
Adon	13	08	66	56
Cape Guardafuy	11	40	71	24
Cape de Baſſos	04	30	65	19
Magadox	02	30	59	24
Molinda	02	S. 42	52	11
Tanga	05	20	52	01
Cape Faſſto	08	02	52	24
Dagnada	15	17	53	26
Cape Corintes	23	30	48	51
Cape St. Marin	25	40	46	59
River St. Luſſea	28	25	46	09
Bay Doliagoa	33	18	43	59

The Sea-coaſt from Cape Bone Eſprance *to* Guiney.

The Places Names.	*South Latitud.* D.	M.	*East Longit.* D.	M.
Iſland Deſiſtian	36	57	11	44
Iſland Degiaiatica	37	56	14	04
Cape Agullas	36	20	33	54
Cape Bonee ſprance	35	50	32	54
Cape Sacos	29	40	30	14
Aſcention Iſland	07	48	05	24
St. Elana	16	03	10	08
St. Elana Nova	16	03	19	48
Baſſas	17	45	27	35
Cape Lado	10	00	29	23
Cape Padron	06	00	29	04
Cape Lopas	01	00	25	21
Anabona Iſland	01	22	22	56
Iſland St. Mathaos	01	40	07	45
Iſland St. Toma	00	N. 10	23	34
Iſland Chocos	00	40	23	50
River Gaboan	00	10	27	16
River de Angai	01	00	27	30
Iſland de Principas	01	50	25	14
Iſland Defarnanda	03	10	26	06
River Borlin	02	42	27	29
River Decainaronas	04	00	27	09

The Sea-coaſt from Samſons *River to the River of* Gambo, *Coaſt* Guiney *and* Barbary.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Old Callabar	04	50	25	15
New Callabar	04	40	23	37
Cape Formoſſus	04	03	22	52
River Binnin	06	50	22	12
River Dallagoa	07	40	19	49
River de Valta	06	05	16	52
Cape 3 Pomts	04	10	13	10
River St. Andraſs	05	23	08	06
Cape de Palmas	04	40	06	05
River de Caſto	05	20	03	48
Cape Mounta	05	23	01	46
Cape Roxo	11	38	6	W. 13
River *of* Gambo	12	47	2	17
Cape de Verd	14	24	6	57

The

The Cape de Verd Iſlands.

The Places Names.	*North Latitud.*		*Weſt Longit.*	
	D.	*M.*	*D.*	*M.*
Abrolho	00	00	16	16
Vigia	03	10	10	01
St. Paul	01	32	14	56
Rochaſs	02	30	16	16
Varo	11	12	21	07
Vigia	12	26	19	48
Abrogo	16	36	10	19
Brava	14	49	15	14
Fogo	14	42	14	56
Lantiago	14	52	14	22
Maya	15	00	14	02
Bonaniſta	15	58	13	49
Sall	17	00	13	26
St. Nicholas	16	30	15	44
St. Lucia	16	50	16	08
St. Tincant	16	55	16	32
St. Antonio	17	07	16	56
Cape Blanco	20	30	9	26
Cape Boyadojo	26	55	2	52
Marquepana	27	22	2	11
Cape Denao	28	52	1	46
Cape Gillam	29	50	1	29
Cape de Garto	30	30	1	25
Cape Cantin	32	27	1	06
Tangiar *Eaſt Longit.*	35	36	1	49

The Sea-Coaſt on the Main, *from* Tangiar *to* Joppa *in the* Straights.

The Places Names.	*North Latitud.*		*Eaſt Longit.*	
	D.	*M.*	*D.*	*M.*
Wadallo *in the* Straights	34	57	3	13
Ballis	34	57	3	48
Oran	35	46	7	59
Tanis	36	30	9	18
Sally	36	40	9	48
Argier	36	40	10	54
Tadallis	36	48	11	25
Ragin	36	50	11	44
Gion	36	50	13	30
Gigaria	37	03	14	26
Colla	37	09	15	14
Stora	37	09	15	44
Bona	37	19	16	44
Bozarat	37	30	17	50
Tunis	36	50	17	24
Cape Beun	37	05	18	11
Suſſa	36	02	18	07
Britto	35	23	18	41
Chereune	34	56	18	36
Cape Mizarrata	32	18	24	00
Cape de Solli	31	1	25	49
Cape Ruſſutta	32	58	29	26
Cape Roattini	32	18	32	04
Alexandria	30	40	41	28
Michallat	30	30	41	55
Cairo	30	35	41	44
Joppa	31	42	43	39

The Coaſt from Antiochia *to* Sagua *in the* Straights.

The Places Names.	*North Latitud.*		*Eaſt Longit.*	
	D.	*M.*	*D.*	*M.*
From Antiochia *to* Sagua	34	54	46	26
Cape Pollopolla	35	35	44	01
Cape Seridioni	35	55	41	24
Cape Decoxman	36	16	36	44
Cape Babarnau	37	58	36	22
Land Miri	39	12	37	05
Incomodio	40	26	40	39
Conſtantinople	40	56	40	33
Gallippollo	40	20	37	59
Cape Degriffa	40	12	37	11
Cape Pimra	40	26	32	23
Cape *St.* George	39	28	32	10
Cape Collo	37	40	32	35
Cape Sille	37	15	31	52
Cape Matapan	36	28	30	53
Caſteltornis	37	45	30	32
Drugromaſtra	38	38	30	40
Cape Liriga	40	18	29	38
Hiraſſa	40	57	30	38
Antavara	41	49	30	54
Cattaro	42	21	29	47
Raguſſa	42	29	28	57
Stanio	42	57	28	11
Trovor	43	30	27	37
Cape Caſta	43	27	26	48
Salconico	44	01	27	24
Zaro	44	05	26	39
Sagua	44	47	25	49

From Cape Fiſtria *to* Giblitore.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Cape Fiſtria	44	40	24	10
Venetia	45	37	22	45
Gorro	44	57	21	35
Giavocha	44	19	21	26
Ancana	43	25	24	29
Angollo	41	31	27	02
Cape *St.* Maſſa	39	52	26	53
Gallipoli	40	08	27	04
Cape Callom	38	50	25	40
Cape Sparta-venta	37	46	24	16
Pollicaſtro	40	08	24	02
Sallarno	40	51	23	32
Napolis	41	08	22	51
Rome	41	50	21	09
Ciritacha	41	46	20	24
Leagueorne	43	28	19	03
Cape Malle	43	51	15	37
Cape Larci	42	58	14	38
Tallone	43	00	14	04
Marſilia	43	12	12	44
Cape Degofrito	41	41	11	18
Cape Pallomallo	40	10	8	39
Cape Martin	38	46	8	20
Allagant	38	20	7	14
Cape Paul	37	28	7	11
Cape Degat	36	47	5	24
Valis	36	49	3	33
Malagoe	36	45	3	07
Giblitore	36	40	2	06

The Iſlands in the Straights, *called the* Archipelago.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Sarſanto	36	57	33	39
Satfo	37	17	33	22
Famania	37	28	33	18
Trava	37	49	34	41
Pipor	39	32	33	51
Laſſor	39	58	33	51
Lamo	39	44	33	38
Stripo	39	16	33	51

The Places Names.	*North Latitude* D.	M.	*East Longit.* D.	M.
St. Penaga	38	52	33	03
Andrea	38	12	34	46
Ipſava	38	28	35	11
Mortalin	38	54	35	52
Staviſratta	39	28	35	14
Lamnoſs.	39	41	35	49
Embroſs	40	09	36	09
Palamos	40	14	36	04
Tuſſa	40	00	35	19
Iſlands in the Straights.				
Sapientia	36	47	30	16
Stouty	37	10	29	43
Zant	37	37	29	38
Cape Sidro	38	15	29	33
Paxa	38	49	29	30
Corfu	39	26	29	26
Faimo	39	44	29	19
Seſſino	40	22	29	14
Pianaſſa	41	52	26	08
Trinite	41	50	25	53
Pollagaſſa	42	17	26	37
Mallida	42	37	28	03
Corſella	42	35	27	38
Aguſta	42	36	27	13
Catſſalla	42	40	27	03
Catſſo	42	44	26	58
Liſſa	43	00	26	33
Buzo	43	02	26	18
St. Androa	43	07	25	58
Poma	43	14	25	48
Iſland Groſſo	44	00	25	36
Sauſſaga	44	20	25	02
Piper	35	52	22	15
Malta	36	00	21	54
Comino	36	15	21	24
East end of Cyprus	34	48	44	18
Middle of Cyprus	34	18	43	09
West End of Cyprus	34	22	41	47
Rhodes	35	40	37	22
Sivia	36	05	37	17
Gozo	34	37	32	39
East end of Candia	35	04	35	32
Middle of Candia	35	08	33	56
West end of Candia	35	15	32	25
Scarpanta	35	10	36	04
Caros	35	35	35	39
Langa	36	33	36	02
Stampalia	36	11	34	59
Levatta	36	38	34	54
Niza	37	02	34	31
Cavari	36	40	32	16
Palla	36	52	32	09

Cardinal

The Places Names.	*North Latitud.*		*East Longit.*	
	D.	M.	D.	M.
Cardinals Hats	37	25	32	31
Ferlconari	36	59	32	37
Millo	36	40	33	19
Goza	35	41	20	51
Samatto	35	46	19	39
Lampadoſſa	35	58	19	59
Linoſſa	36	20	20	05
Pantalaria	36	53	19	35
Kambro	37	10	18	34
Maritimo	37	52	20	02
Maſſina	38	07	23	21
East end of Sicilia	37	07	23	24
Middle of Sicilia	37	42	22	09
Weſt end of Sicilia	37	52	20	07
Uſtica	38	50	20	58
Allicur	38	45	21	47
Falliteur	38	43	22	01
Liſtallin	38	34	22	32
Lipari	38	40	22	27
Volcana	38	48	22	30
Stromballo	39	03	23	02
Foldemaſſina	38	20	23	29
Iſcia	40	46	21	36
Ponuſſa	40	40	20	32
Palmarolla	40	50	19	59
Ginnute	41	59	19	48
Gigio	41	58	19	39
Criſta	41	55	18	51
Planoſſa	42	07	18	33
Lilbo	42	31	18	36
Caprera	42	58	18	21
Gargona	43	20	18	28
North end of Corſica	42	55	17	26
Middle of Corſica	42	05	17	07
South end of Corſica	41	20	17	01
Taloro	40	56	17	19
Azanera	41	08	16	22
North end of Sardinia.	41	10	17	25
Middle of Sardinia.	40	06	16	54
South end of Sardinia.	38	56	16	37
The Iſland of St. Pedra	39	20	16	03
Pallmade ſollo	39	11	16	05
Sarpentara	39	00	17	18
Callatta	37	57	16	28
Minorke	39	55	12	16
Mayorka	39	38	11	12
Cabrea	39	07	11	05
Collombratta	39	50	08	44
Eviſſa	39	05	09	57
Formentara	38	44	09	54

The Canary Iſlands.

The Places Names.	*North Latitud.*		*Weſt Longit.*	
	D.	M.	D.	M.
Forta Ventura	28	12	06	28
Sanſlorrotta	28	51	06	08
Allegranſſa	29	14	06	13
Grand Canary	27	43	08	31
Tenarife	28	20	09	28
Gomara	28	09	10	15
Faro	28	05	10	43
Palma	28	58	10	42
Salvagas	30	05	08	57
Dazarts	32	08	09	46
Madara	32	27	11	19
Por. Santo	33	14	10	09

The Weſtern Iſlands.

The Places Names.	*North Latitud.*		*Weſt Longit.*	
	D.	M.	D.	M.
Abraoſo	37	55	29	46
Vaſo	40	30	27	28
Corvo	40	09	24	59
Flauris	39	30	24	55
Fiall	38	49	22	13
Pico	38	30	21	37
St. George	39	00	21	20
Traſſara	39	31	20	22
Gratiaſſa	39	30	21	11
Abrajo	39	52	18	53
Vajo	38	43	18	23
St. Michael	38	00	18	16
Horningo	37	25	17	36
St. Maria	37	00	17	56
Vejo	42	22	18	56
Iſland Varda	44	48	22	46
Maiden Iſland	46	30	23	36
Old Brazeel	51	03	09	58

The Sea-coast of Portugal *and* France, *from* Cales *to* Callis.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Cales	36	32	1	24
Cape *St.* Maria	36	52	0 *We.*	24
Cape *St.* Vincent	37	00	1	18
Lisbone	39	08	1	06
Rock *of* Lisbone	39	00	2	04
Burlings	39	43	2	28
Isles *of* Boyon	42	22	2	00
Cape Finisterre	43	10	2	55
Cape Corian	43	21	2	56
Sazarka	43	38	1	52
Cape Artingal	44	08	0	06
Cape Pinas	44	04	0 *Ea.*	52
Lyons	43	49	2	06
St. Andrea	43	43	2	36
Bilbo	43	41	3	20
St. Abastian	43	40	4	19
Burdeux	45	10	5 *Ea.*	44
Bloy	45	28	5	19
Shorant	46	00	4	56
Rochel	46	17	4	54
Toppar	45	36	3	29
Mamosin	45	49	4	34
Olloron	45	58	4	30
St. Martins	46	16	4	29
Barges	46	30	3	54
Uss	46	44	3	20
Piller	47	04	3	22
Nants	47	45	4	15
Radon	47	55	3	33
The Coasts of Britanny.				
Cardinals	47	27	2	24
Ballile	47	19	2	14
Groy	47	35	1	54
Glannats	47	33	1	34
Pennes, *or* Pennemark	47	35	1	10
Paiker	48	00	0 *We.*	01
Seames	48	04	0 *Ea.*	23
Camarita Bay	48	25	0	56
Brist	48	35	0	59
Conquer	48	45	0	19
Ushant	48	48	0	05
Island *of* Basse	49	01	1	27
Morlias	48	54	1	39
Satta Isles	49	7	2	02
St. Mallas	48	45	3	39
Chosol	49	5	3	44
Boffin	49	19	3	42
Jarze	49	30	3	24
Sark	49	37	3	09
Garnasse	49	43	2	49
Arme	49	48	3	05
Caskats	50	7	3	09
Arderny	50	2	3	37
Cape Hag.	50	4	3	52
Cape Barflaw	49	57	4	32
Rone	49	46	5	54
Saine Head	50	4	5	28
St. Vallari	50	8	5	29
Deip	50	15	6	39
Callis	51	13	7	16

The Sea-coast of England *from the* Lizard *to* Newcastle.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
The Lizard	50	10	00	00
Falmouth	50	22	00	12
Foy	50	35	00	34
Ramhead	50	34	00	49
Plymouth	50	36	00	51
The Edistone	50	22	00	44
The Start	50	27	1	19
Dartmouth	50	37	1	28
Torbay	50	42	1	36
The Bary	50	40	1	35
Absom Bar	50	47	1	37
Lime	50	55	2	10
Chiddock	50	57	2	14
Portland	50	50	2	36
Weymouth	51	3	2	44
Pool	51	43	3	34
Isle *of* Wight	50	58	4	08
Portsmouth	51	8	4	24
Shoram	51	7	4	57
Beache	50	58	5	15
Rye	51	13	6	09
Dongeness	51	9	6	15
Dover	51	25	6	32
Ripraps	51	13	6	49
The South Foreland	51	22	6	44
The Downs	51	25	6	45
Sandwich	51	27	6	33

North

The Places Names.	*North Latitud.* D.	M.	*Eaſt Longit.* D.	M.
North Foreland	51	28	6	44
Margaret	51	29	6	34
Quinborow	51	30	6	01
Rocheſter	51	28	5	54
London	51	30	5	24
Graveſend	51	35	5	44
Tilbury Hope	51	38	5	54
Colcheſter	52	04	6	02
Harwich	52	11	6	27
Ipſwich	52	14	6	24
Orfordnaſs	52	20	6	35
Alborow	52	24	6	39
Yarmouth	52	45	6	42
Winterton	52	52	6	46
Cromar	53	20	6	41
Blackneſs	53	4	6	19
Wells	53	7	6	02
Lin	52	58	5	33
Boſton	53	9	5	02
Grimsbe	53	39	4	28
Hull	53	45	4	16
The Sporne	53	45	5	01
Burlington	54	00	4	28
Flamborough Head	54	8	4	35
Scarborough	54	20	4	21
Whitby	54	35	4	10
Hartlepool	54	37	3	29
Sinderland	54	42	3	26
Shelles	55	02	3	24
Newcaſtle	54	58	3	14

The Coaſt of Scotland.

The Places Names.	*North Latitud.* D.	M.	*Eaſt Longit.* D.	M.
Barwick	55	49	2	39
Leith	56	3	2	09
Dondee	56	26	2	17
Aberdeen	57	22	2	29
Bafom Naſs	57	48	1	34
Cat Naſs	58	37	1	38
Iſles *of* Orkney	58	50	2	02
Fair Eſle	59	30	3	19
Shetland	60	22	2	54
Fair Head	58	43	2	*W.* 21
Iſland Lewes	58	30	2	48
Skey Iſland	57	40	2	3

The Sea coaſt of Flanders *and* Holland *from* Callis *to the* Scaw.

The Places Names.	*North Latitud.* D.	M.	*Eaſt Longit.* D.	M.
Duynkirk	51	18	7	49
Oſtend	51	30	8	29
Sluice	51	38	9	11
Zealand	51	48	9	05
The Brill	52	8	9	08
Antwerp	51	37	9	46
Rotterdam	52	5	9	48
Amſterdam	52	40	10	01
The Taſſel	53	20	10	16
The Uly	53	30	10	12
Skelling	53	35	10	14
Amaland	53	40	10	16
Embden	53	44	11	06
Breme	53	50	12	26
Hambrough	54	4	13	26
Holikeland	54	30		
Stonar	55	17	12	08
The Scaw	57	52	13	51

The Sea-coaſt from the Lizard *to* Holy-head.

The Places Names.	*North Latitud.* D.	M.	*Weſt Longit.* D.	M.
Lands end	50	20	0	34
Gulfe	50	11	1	22
Scilly	50	7	1	21
7 Stones	50	18	1	16
Hasty Point	51	10	0	*E.* 19
Londy	51	20	0	*W.* 3
Holmes	51	26	1	*E.* 44
Briſtol	51	29	2	34
Gloceſter	52	3	2	39
Caldy	51	53	0	10
Milford	52	5	0	*W.* 6
Ramza	52	12	0	38
Studwalls	53	12	0	04
Barrs	53	13	0	*W.* 16
Weſtcheſter	53	37	0	*E.* 04
Holy-head	53	44	0	26
Iſle *of* Man	54	25	0	36

The

The Sea-coast of Ireland.

The Places Names.	*North Latitud.*		*West Longit.*	
	D.	*M.*	*D.*	*M.*
Lamby	44	44	1	46
Dublin	53	32	1	56
Wexford	52	33	1	44
Waterford	52	30	2	24
Corke	52	01	2	56
Kingſail	51	52	3	08
Old Head	51	40	3	14
Mizand Head	51	28	5	21
Cow and Calf	51	42	5	42
Skillukes	52	00	6	06
Blaskos	52	15	6	11
Limbrick	53	04	4	51
Loopas Head	52	44	5	41
Gally Head	53	20	5	36
Galloway	43	40	5	16
Iſles *of* Aion.	53	21	6	36
Slages	54	27	6	21
Iſles *of* Are	55	18	5	36
Fore Head	55	38	4	56
Fair Foreland	55	35	2	36

The Sea-coaſt of Iſeland-Iſland.

The Places Names.	*North Latitud.*		*West Longit.*	
	D.	*M.*	*D.*	*M.*
Mage Naſs	61	32	2	51
Merchant Foreland	63	52	11	42
Horn	63	42	10	16
Silly	64	50	9	56
Bargafar Point	65	27	7	01
Long Naſs	66	26	7	36
Grimſa	66	42	9	20
Marza	67	8	9	42
Rage Point	66	40	12	00
Fair Foreland	65	40	14	53
Snow Hill	65	11	14	50
Rook Point	64	00	14	09
Weſt main Iſles	63	17	12	53
Gammat Iſles	63	48	15	06
Grimes Hole.	63	23	15	46

The Sea-coaſt In the Sound.

The Places Names.	*North Latitud.*		*East Longit.*	
	D.	*M.*	*D.*	*M.*
Lizol	57	35	14	9
Anall	57	8	14	41
Elſen-nore	56	40	15	21
Copenhaven	56	17	15	18
Mooan	55	41	15	29
Witmond	55	20	16	32
Iſmond	55	20	16	44
Burnthom	56	00	17	40
Erthholm	56	10	17	38
Gathe ſand	56	15	22	03
Farro Sound	58	48	21	53
Gotland	58	20	21	22
Heda	55	53	21	29
Dormamel	56	55	23	44
Dines Naſs	58	22	23	55
Righa	57	50	26	25
Runen	58	38	25	14
Parun	58	52	26	54
Shorham	58	58	26	30
Wile	59	6	25	6
Ardenbro	59	5	24	6
Dagaratt	59	44	23	55
Ogſholm	59	58	24	32
Norgin	60	10	25	14
Eaſt Rand	60	12	28	41
Wibro	61	16	30	00
Wakato	61	16	29	42
Patting	61	00	28	45
Burga	61	2	27	14
Roſtbrugh	61	3	25	04
Abbo	61	8	23	28
Buſhoers	60	9	21	54
Stockholm	58	49	20	6
Frouenboro	58	48	18	16
Stickholm	58	23	18	24
Yaffro	58	10	18	58
Fuland	57	42	19	12
Chiping	56	53	18	27
Faſtinboro	56	2	15	49
Scarlet Iſland	56	46	16	02
Elſinbro	56	46	16	00
Cape Cole	57	00	15	36
Nading	57	53	15	04
Holm Sound	59	8	13	44
Mordo	58	37	12	2
Walle Sound	58	25	11	40
Long Sound	59	7	12	54

From

From Naze *of* Norway *to* Archangel.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
The Naze *of* Norway	58	00	10	26
Stave Angor	58	57	9	44
Out Shers	59	7	8	30
Bomal	59	31	9	04
Harla Iſland	60	24	9	02
Katts Naſs	61	54	8	06
Swin	62	40	9	10
Gallee	62	52	9	46
Gripo	63	40	11	26
Roſs Illes	67	1	13	30
Werro	67	38	13	52
Lowfat	68	30	14	40
Zanham	70	28	18	32
Aſſumption	71	7	20	38
North Cape	71	22	22	6
Skitanboro	70	56	24	2
Iſland Kilding	68	54	26	16
Cape Race	65	49	29	28
Cape Gallant	67	11	28	56
Cape Crace	65	17	28	54
Fox Naze	64	12	26	31
Archangel	63	22	26	46

The Coaſt of Greenland.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Cherri Iſland.	74	34	20	32
Hope Iſland	76	13	23	16
Hopeleſs Iſles	77	00	22	54
Nageo Point	77	10	23	38
Duckus Cone	77	45	22	54
Cape Blande	78	25	23	26
Helis Sound	79	27	24	19
Point Lookout	76	25	20	18
Horn Sound	77	7	20	00
Ball Sound	77	34	20	3
Foe Sound	78	38	20	45
Beare Sound	79	15	19	55
Black Point	78	32	18	34
Cape Cold	79	00	17	56
Fair Foreland	79	15	19	29

The Coaſt of the North-Weſt Diſcovery.

The Places Names,	*North Latitud.* D.	M	*Weſt Longit.* D.	M.
Cape Farewell	59	00	41	50
Sir Thomas Smith's Bay	79	10	79	50
Bottom's Iſles	60	20	62	50
Beliſle	51	2	48	44
Where the Table is begun, on the Coaſt of Terra Nova.				

By multiplying the *Hours* by 15, and dividing the *Minutes* of *Hours*, if there be any, by 4, ſo will the number of *Degrees* ariſe; and if there remain any *Minutes* after the *Diviſion*, they muſt be multiplied again by 15, and ſo will the number of *Minutes* of *Degrees* ariſe, by which theſe Places are diſtant from each other, which *Diſtance* is called the *Difference* of *Longitude* of that Place for which the *Tables* were calculated, if the other Place be *Eaſtward* of the firſt; but if it be more *Weſtward*, it is to be ſubſtracted from the *Longitude* of the other.

And this is the way we have endeavoured to ſettle the *Longitude*, with as much neerneſs to the truth as poſſible we could. I have not only made uſe of my own Calculation of the *Difference* of *Meridians* of Places, as I have often uſed at *Barbadoes* and *Virginia*, or any other Place, from the *Meridian* of the *Lizard*; but I have alſo obtained them from the beſt *Geographical Charts* that are yet diſcovered, and the lateſt *Tables* made; and ſo by conſulting with the able and skilful *Mariners*, that have uſed the *Eaſt* and *Weſt India*; by the firſt we have informed our ſelves for the ſetling the *Longitude* of Places in the *Eaſt India*, with the beſt approved *Authors*: as in *page* 161 of *Harmonicon Cœleſte* we find the *Difference* of *Meridians* betwixt *Calicut* in *East-India* and *London* to be 5 *hours* and 50 *min.* which being converted into *Degrees* and *Minutes* as before directed, is 37 *deg.* 30 *min.* the *Difference* of the *Meridian* of *London* and *Calicut*; and the *Difference* of the *Meridian* of *London* and the *Lizard*,

5 *deg.* 24 *min.* added to it, gives the *Difference* of the *Meridian* of *Calicut* and the *Lizard*, it makes 92 *deg.* 54 *min.* the *Difference* of *Longitude* to the *Eastward* of the *Meridian* of the *Lizard*.

And *Macao* in the Kingdom of *Pegu*, whose *Difference* of *Meridians* with the City of *London* is 7 *ho.* 9 *min.* which is 107 *deg.* 15 *min.* the former *Difference* added makes *Macao* to the *Eastward* of the *Lizard* 122 *deg.* 39 *min.* The *Difference* betwixt the *Tables* before-going, and the *Eclipses*, in the *Difference* of *Meridians* of *Calicut* and *London*, is very small, the *Tables* 4 *min.* more; and the *Difference* between the *Eclipses* and the *Tables* is 22 *min.* more. Then the Observation of *Macao* and *London*, being so small, it may very well be born withal: And we have setled the *Longitude* of the *West India*, according to long and approved Experience of *Voyages* of my self and others, from the *Lizard* to *Barbadoes*, and to *Cape Henry* and *Charles* the *Capes* of *Virginia*.

The *Latitude* of a Place is the *Distance* of the *Zenith*, or the *Vertical Point* thereof from the *Æquator*, or the *Height* of the *Pole* elevated above the *Horizon*. You have been shewed several ways already, for the finding the *Poles* Elevation above the *Horizon*: but this *Rule* will not be impertinent to this Place, being not named before, which is by the *Stars* thus.

You must observe some *Fixed Star* in the *Heavens*, which is neer the *Pole*, and that never sets in that *Region*: Thus, you must observe the least and also the greatest *Altitude* of the said *Star*, when he doth come to the *Meridian* under the *Pole*, and also above the *Pole*; which done, you must add the least *Altitude* to the greatest, and so the half of the *deg.* and *min.* thus numbred together, will be the Elevation of the *Pole*, or *Latitude* of the Place.

An *Example* whereof may be this. The first *Star* of the three in the *Tail* of the *Great Bear*, in his least *Altitude*, observed at *Bristol*, is about 10 *deg.* 59 *min.* and the greatest *Altitude* of the same, when he is above the *Pole*, is found to be neerest 91 *deg.* 59 *min.* both which *Numbers* being added together, do make 102 *deg.* 58 *min.* the half of that same is 51 *deg.* 29 *min.* the true *Latitude* or *Elevation* of the *Pole*.

You may take notice, I begin the *Longitude* at the *Meridian* of the most *Southern* Parts of *England* at the *Lizard*, and increases on each side of that *Meridian*, from 1 *deg.* to 180 *deg.* both *Eastward* and *Westward*; therefore you must note, That by these *Tables* all Places, that lie to the *Eastward* of the *Meridian* of the *Lizard*, are called *East Longitude*; and all Places on the *West* side of the *Meridian* of the *Lizard*, is called *West Longitude*.

Therefore a *Ship* being in *East Longitude*, sailing to the *Eastward*, she increaseth her *Longitude*; but sailing to the *Westward*, it decreaseth. And likewise if a *Ship* be to the *Westward* of the *Lizard*, that is, in *West Longitude*, and saileth to the *Westward*, the *Longitude* increaseth; but sailing to the *Eastward*, the *Longitude* decreaseth.

You must note, the *Sun* riseth to the *Eastward*, therefore all the *Stars*, and are carried *West*; and that all Places that are to the *Eastward* of the *Meridian* of the *Lizard*, the *Sun* comes to their *Meridian* first, according the time it is to the *Eastward* of the *Meridian* of the *Lizard*: As you may note what was before directed, That every 15 *deg.* is an *Hour*, and 4 *min.* a *Degree*: Therefore in the former *Example* of *Calicut*, whose *Difference* of *Meridians* is 5 *ho.* 50 *min.* that is to say, the *Sun* is on the *Meridian* in the *East Indies* at *Calicut* at 10 *min.* past 6 a Clock in the morning here at the *Lizard*, that is, 5 *ho.* 50 *m.* sooner than he comes to the *Meridian* of the *Lizard*, to make here 12 a Clock at Noon. And so on the contrary, lesser to the *West* by every 15 *deg.* As for *Example*.

The *Difference* of *Longitude* betwixt the *Meridian* of the *Lizard* and *Barbadoes* is 52 *deg.* 58 *min.* that converted into *Time* is 3 *hours* 42 *min.* the time the *Sun* comes to the *Meridian* of the *Lizard*, before it comes to the *Meridian* of *Barbadoes*; that is to say, it is our 3 a Clock 42 *min.* past at the *Lizard* in the afternoon, before it is 12 at Noon in the *Barbadoes*.

You may take notice, I took my first *Latitude* and *Longitude* from the *Northern parts* of *Newfound-land*, to the *Westward* at *Cape Homblanto*, neer *Bell-isle*, and so have coasted all round the *Bay* of *Mexico*, and taken the *West India Islands* in the way,

and

and ſo round the *Coaſt* by *Brazil*, and through the *Straights* of *Magellane* to *Nova Albion*, where Sir *Francis Drake* was on the back ſide of *New-England*, in the *South Sea*; and from thence to the *Eaſt India*, firſt the *Iſlands*, and then the *Main Land*, and back by *Cape Bon Eſprance*, and round the Coaſt of *Guinney* and *Barbary* down from *Tangire*, and upon the *Chriſtian Shore* to *Gibliture* and *Tocke* in the *Canary Iſlands* and *Weſtward Iſlands*, and ſo along the *Coaſt* from *Calez* to *Callis*, and from the *Lizard* to *Newcaſtle*, and from thence along the Coaſt of *Scotland* to *Skey Iſland*, and along the Coaſt from *Calis* to the *Scaw*, and along the Coaſt from the *Lizard* to the *Iſle of Man*, and round the Coaſt of *Ireland* to the *Sea-coaſt* of *Iſeland*, and ſo from the *Scaw* round the *Sound*, by the *Naſe* of *Norway* to *Archangel*, and about by the *Sea-coaſt* of *Greenland* by the *North-weſt Diſcovery*, to the *Coaſt* of *New-found Land*, where firſt I began; whereby you may ſee I have traced a Path, or coaſted round to the moſt Chief *Harbours*, *Head-lands*, and *Iſlands* in the World, by the *Tables*. And ſo I ſhall conclude with theſe *Verſes* in Mr. *Philips's Preface*.

When Drake *and* Candiſh *Sail'd the World about,*
And many Heroes *found new* Countries *out*
To Britains *Glory, and their laſting Fame:*
Were we like-minded, we might do the ſame.

The End of the Fourth Book.

STURMY's
MATHEMATICAL
AND
Practical Arts.

The Fifth Book.

SHEWING

A new Way and *ART* of *SURVEYING* of *LAND* by the *MARINERS AZIMUTH* or *AMPLITUDE-COMPASS*; By which you may *SURVEY* and *PLOTT* with eaſe and Delight, all manner of *Grounds*, either ſmall Incloſures, Champions, Plains, Wood Lands, or any other Uneven Grounds.

AND ALSO,

How to take the *Plott* of a whole *Town*; and a moſt Excellent way to be ſatisfied whether his *Plott* will Cloſe, before he begins to *Protract* the ſame.

ALSO,

The *ART* of *GAGEING* all ſorts of Veſſels, as Cube-Veſſels; or to Meaſure Square Veſſels, as Cylinder Veſſels, and Pipes, Hogſheads, and Barrels: and to Meaſure Veſſels that are part out; And alſo to Meaſure Brewers Tuns, or Oval Tuns, or Maſh-Fats, or Cone-Veſſels, or Brewers Coppers, or any other Veſſels.

AND LIKEWISE,

How to Meaſure exactly all kind of Plain Superficies, as Walls, Timber Work, Roofs of Houſes, Tyling, Board, and Glaſs, and Wainſcot, Pavement, and the like; As alſo Timber and Stone; And of Meaſuring of SHIPS.

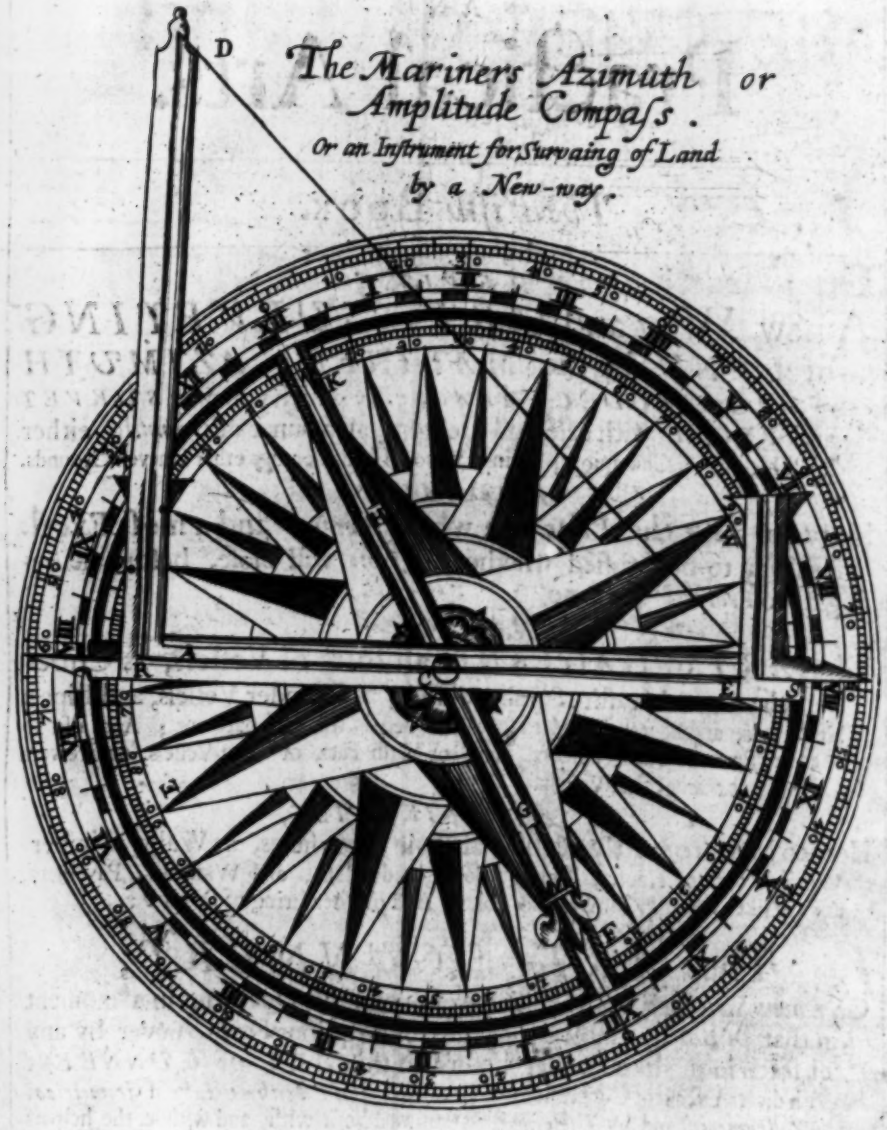
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By Capt. *SAMUEL STURMY.*

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The Mariners Azimuth or Amplitude Compaſs.

Or an Inſtrument for Survaing of Land by a New-way.

The AUTHOR to his Fifth BOOK.

HEre comes a *Critick*, cloſe thy Page,
Thou art no Subject for this Age:
And Cenſure oftentimes you know
Will ſtrike the *Dove*, and ſpare the *Crow*.
But hold; thy Guilt does not require
That thou ſhouldſt lurk, or yet retire.
Be open as the Eye of Noon,
And let the Dogs bark 'gainſt the Moon;
Thou haſt no Luſtre of thy own
But what's deriv'd from *Art* alone.
Fear not, thy *Art* inſtructed Page
May either pleaſe, or teach the Age.

The ART of Surveying of Land By the SEA-COMPASS:

The DESCRIPTION of the *COMPASS*, and *STAFF*, and *CHAIN*.

The Fifth Book.

CHAP. I.



Have been all this while a ſhewing the *Mariner*, How to deſcribe and make his own *Inſtruments*, and the uſe thereof in *Navigation*; I am alſo willing to ſhew him the great uſe there may be made of his *Sea-Compaſs*, commonly called the *Azimuth*, or *Amplitude-Compaſs*, which all ingenious *Mariners* carry to *Sea*.

This *Compaſs* requires but little deſcription, it being ſo well known to all Sea-men; for it is the ſame in a manner as they Steer the Ship by: But it is called by the name of a *Meridian Compaſs*. The *Chart* within the Box is divided as you ſee in this Figure, each quarter into 90 Degrees, beginning at North and South, numbred Eaſt and Weſtward; on the Glaſs there is a Braſs Circle, and Diameter, that goes over the Center of the *Compaſs-Chart*, the Braſs Circle is about 7 $\frac{1}{3}$ Inches Diameter, and about $\frac{6}{10}$ of an inch broad; The outward Circle is divided into 360 Degrees by 90 Degrees in each Quarter, as you ſee the former was; the Figure makes all plain to the meaneſt capacity, and numbred as you there ſee from 1 Degree each way from each oppoſite Point; The inward Circle is the Hours anſwering each 15 Degrees and Quarters of the *Horizon*, and they are numbred as you ſee in the Figure.

There is a Circle the like divide the high of the Needle and *Box-Chart*, with lines drawn up the Box at 90 Degrees every way, that the Degrees of the upper Circle, and lower Circle, and *Chart*, may agree.

In the Diameter FGHK there is a right Line drawn in the midſt, as GH, and at each end is two ſlits of an inch and an half long, each of them, as FG and HK; which are cut right in the middle: by which in taking any Angle, you muſt be ſure to ſet the North Point right under the ſlit and line of the one; and the South Point under the ſlit and Line of the other: and ſo muſt you always, when you take the Angle of any

two ſtations from one place to another, You muſt be ſure to keep the two ſlits in the Braſs Diameter over the North and South Point of the *Chart*; and turn the *Index* that is riveted to the Center at C to the Object, and look through the ſights that ſtand upon it; when you find you ſee it plainly, and have made a good obſervation of the Angle, look what Degrees the edge of the *Index* cuts, and upon what Quarter of the *Compaſs*: and that number of Degrees is the Angle of the two places from the *Meridian*.

The ſights that ſtand perpendicular on the *Index* are 1 inch and ¼ long; the further ſight hath a wire that goeth through the midſt thereof, by which we cut the Object: that ſight next unto you hath only a ſlit.

Through which you muſt ſee the Wire and Object you look at in one and the ſame Line, when you make any Obſervation.

Betwixt the two ſights is a right line drawn through the midſt, and at the further ſight is faſtened a perpendicular of Braſs with a right line through the midſt as B L: this perpendicular is faſtned with two ſmall Braſs ſcrews at M: O to the further ſight with a wire; and at D is a hole where is faſtned a Silk thred twiſted and ſcrewed through a ſmall hole in the Eye-ſight at S, and faſtned with a ſmall wooden pin.

The Uſe of the *Azimuth-Compaſs*.

And this is for to take the Sun's *Azimuth* at any time of the day, by turning the Eye-ſight to the Sun; and the ſlits over the North and South point of the *Chart* (as before directed) you may ſet the *Index* to what Degree you pleaſe; and when the ſhadow made by the Thred D S, comes upon the Line in the midſt of the *Index* on the Line S A, and on the perpendicular Line R D; then on that inſtant take the Sun's Altitude by a *Quadrant* or *Staff*, and note it down: and likewiſe the Degrees cut by the *Index* at the perpendicular end, and that is the Sun's Magnetical *Azimuth* at that time. When you have done, you may unſcrew the perpendicular from the ſight; and then you have the *Compaſs* ready to take an Amplitude of the Sun's Riſing or Setting: but more of that in the following Treatiſe, when we ſhall touch upon *Aſtronomy*.

The *Amplitude Compaſs*.

When you make uſe of the *Compaſs* for Surveying of Land, you have a Braſs ſocket ſcrewed faſt to the bottom of the inward Box that holds the *Chard*; In that ſocket you put the head of your three legged *Surveying-Staff* with a ſmall ſcrew on the ſide to faſten it to the head, that it may not ſtir when the *Compaſs* is ſet North and South as before directed; then you may turn the *Index* and ſights to what object you pleaſe, and be ſure of your Angle from the Meridian if your *Chard* be good, and the Needle well touched and placed. Thoſe that make them ſhould have a ſpecial care of that; and that the points of the Needle be faſtned and cemented together with a little Tin, ſo that they do not ſtir abroad, as I have ſeen many *Charts* careleſly made, doth; It might be to the ſhame of them that make them; and likewiſe the Wires put off one ſide 5 Degr. more or leſs, as if in all places there were ſtill a Point-variation, which is a lazy trick as well as faulty in moſt places. I would adviſe all Ingenious *Mariners* to make a conſtant practice of taking obſervation of the Sun's Altitude or *Azimuth*; and Steer a Courſe, and make allowance accordingly, as hath been ſhewed elſewhere, with the Wires of the Needle put exactly under the Meridian, as this *Compaſs* before-going the Points are; and then in all things this *Inſtrument* will come to the Truth, as well as a *Needle* of greater charge, and *Plain Table* and their appurtenances of 3 *l.* price: or the *Theodolite*, and *Circumferenter* and *Veracter*. And yet I cannot but highly commend theſe *Inſtruments* as very uſeful for *Land-men* which have Money enough. Neither dare I reject as uſeleſs, either the *Topographical Inſtrument* and *Croſs-Staff* of Mr. *Diggs*, the *Familiar Staff* of Mr. *John Blagrave*, the *Geodetical Staff*, and *Topographical Glaſs* of Mr. *Arthur Hopton*, the *Sector Croſs-Staff*, and the *Pandoron* of Mr. *George Atwel*, or any other witty Invention which hath been deviſed for the Exact Plotting, and Speedy Meaſuration of all manner of *Superficies*, as *Land*, and the like. But in regard the Authors have in their own Works to their exceeding Commendation deſcribed the Making and Uſe of the ſaid *Inſtruments*, I ſhall ſay no more.

How the *Needles* of the *Compaſs* muſt be ſet.

Of the Devices of *Inſtruments*.

And for the *Mariners Compaſs* in a manner to do the ſame things for the *Surveying* of *Land*, or *Plantations*, or the like, I hope will be well taken and accepted of all Ingenious *Mariners*, for whoſe ſake I take theſe pains.

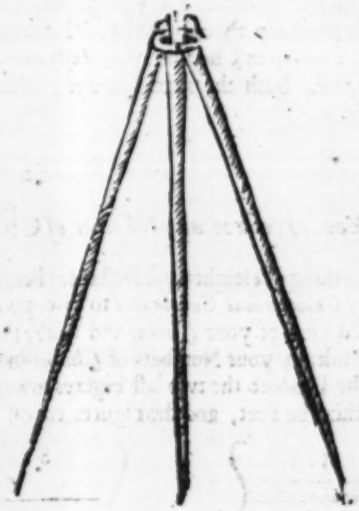
Let the Glaſs over the *Chard* be as clear as poſſibly you can get him.

The

The Figure of the *Staff* is plain, it needs no further description: It is to be had at any *Instrument-Makers*. The *Staff*.

Of Chains, *the several sorts thereof.*

Of *Chains* there are several sorts, as namely *Foot-Chains*, each *Link* containing a Foot or 12 Inches; so the whole *Pole* or *Perch* will contain 16 ½ *Links* or Feet according to the Statute *Pole*.



The *Chains* now used and in most esteem among *Surveyors* are Three. The First I will name is Mr. *Rathborn's*, which had every *Perch* divided into 100 Links; and that of Mr. *Gunter's* which had 4 *Perches* or *Poles* divided into 100 Links: so that each Link of Mr. *Gunter's Chain* is as long as Four of Mr. *Rathborn's*. And this year Mr. *Wing* hath described a *Chain* of 20 Links in a *Perch* for the more ready use thereof in his Art of *Surveying*; Therefore when we have taken the *Angles*, and Plotted a piece of Ground, we will shew how to know the contents thereof in *Acres*, *Roods*, and *Perch* by the two last *Chains*.

SECT. I.

Mr. *Gunter's* Chain.

MAster *Gunter's Chain* is a *Chain* most used amongst the *Surveyors* of this Age, and is always made to contain 4 *Poles*, and each *Pole* 25 *Links*, and each Link 7 Inches $\frac{92}{100}$ of an Inch, and each *Pole* according to the Statute contain 16 ½ Feet, the whole *Chain* is 100 Links in the Four *Pole* or 66 Feet. In measuring with this *Chain* you are to take notice of only *Chains* and Links; saying, such a line measured by the *Chain* contains 64 *Chains* 45 Links, or thus distinguished 64. 45. and this is all you take notice of in *Surveying* of *Land*.

Now for the ready counting of the *Links*; at every *Perch* let there be two Curtain-Rings fastned, and one Ring at every 5 *Links*: so you may readily count the Rings at either end. If the Ingenious *Mariner* wants a *Chain*, he may mark a six Thred-line or small Belch as before directed with Red Cloth marks and White for distinction, or bits of Leather as we mark our *Dipsey line*; and be sure to stretch him well first; or if you can, let it be a *Top-gallant Brace* half worn; then measure them exactly: and mark him as before directed, and you may measure any place of *Land* or *Plantation*, or any distance, as well in dry weather, as with a *Chain*, without sensible Errour.

SECT. II.

Cautions to be used, and to be observed in the use of any Chain.

WHen you have occasion to measure large distances, or otherwise, you may by chance mistake or miss a *Chain* or two in keeping your account, which will breed a considerable Errour; and also in measuring of distances, in going along by a Hedge side you can hardly keep your *Instrument-Chain* & mark in a right line; and therefore the distance will be more than in reality it is. For avoiding these mistakes you ought to provide ten small sticks, which let him that leadeth the *Chain*, carry in his Hand before; and at the end of every one of those *Chains*, stick one of these Sticks or Arrows into the Ground,

Ground, which let him that followeth take up; ſo going on until the whole number of Sticks be ſpent, and then you may conclude you have meaſured Ten *Chains* without further trouble: and theſe Ten *Chains* if the diſtance be large, you call a *Change*, and ſo you may denominate every large diſtance by *Changes*, *Chains* and *Links* in a piece of Paper you keep the account by. If the diſtance be far, you muſt ſet up a Cloth upon a Stick for a mark betwixt your *Inſtrument* and the further mark, and ſee through your *Inſtrument* both the marks in one; then you may be ſure to go ſtraight with the *Chain*.

SECT. III.

How to reduce any Number of Chains *and* Links *into* Feet *and* Yards.

IN taking of Heights and Diſtances hereafter taught, it is neceſſary in the Practice of my *Geometrical Concluſions* to give your meaſure, in ſuch caſes, in Feet and Yards by reducing of your *Chains* and *Links* thus.

Multiply your Numbers of *Chains* and *Links*, as one whole Number by 66, cutting off the Product the two laſt Figures towards the right Hand; ſo ſhall the Figures to the left Hand be Feet, and the Figures cut off ſhall be 100 parts of a Foot.

Examples.

5:32	8:06	Let it be required to know how many Feet are contained in 5 *Chains*, 32 Links. Set down the *Chains* and *Links* with a *Comma* (:) thus and theſe Multiplyed by 66, the ſum will be 351 Feet and $\frac{12}{100}$ parts of a Foot as thus you ſee it ſtand 351:12. This is the Rule by Mr. *Gunter's Chain*.
66	66	
3192	4836	
3192	4836	
351,12	531,96	

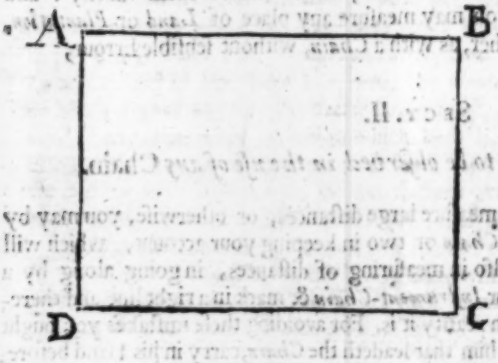
2
351,117
333

If you divide the Feet by 3, the *Quotient* will be 117 Yards. Now if you have leſs than 10 *Links* as 6, you muſt always remember to put (0) to ſupply before the 6, and Multiply the number as you ſee in the laſt Example.

SECT. IV.

How to caſt up the Content of any piece of Land *in* Acres, Roods *and* Perches *by Mr.* Gunter's Chain.

BY a Statute made the 33 of EDWARD the I. an *Acre* of Ground ought to contain 160 ſquare *Perches*, and every *Rood* of Land 40 ſquare *Perches*, and every *Perch* contains 16 $\frac{1}{2}$ Foot, and 4 *Perches*, *Poles*, or *Luggs* in breadth, and 40 in length makes an *Acre*: which multiplyed together is 160, Half an *Acre* is 80, a Quarter 40 ſquare *Perches*.



Suppoſe the Figure ABCD were a ſquare piece of Ground as the *Marſh* of *Briſtol*, and were 15 *Chain* 16 *Links* every way: Then to find how many *Acres*, *Roods* and *Perches* are in it, do thus. Square the ſides, that is, Multiply one in the other, and cut off the 5 laſt Figures to the right Hand, and that before is *Acres*: what remains Multiply by 4 (for 4 *Roods* makes an *Acre*) and cut off 5 Figures as before, and the *comma*: is *Roods*; and that which remains

remains, *multiply* by 40 the *number* of *Perch* in a *Rood*, and cut off 5 *Figures* to the *right hand* of the *Product*; and in like manner you have the odd *Perches*. This *Example* will make all clear and plain.

So you will find 15 *Chains*, 16 *Links Multiplyed* together, as before directed, will produce 22,98256: the 5 laſt *Figures* cut off to the *left hand*, remains before the *Comma* 22, which is 22 *Acres*, and the 5 *Figures multiplyed* by 4, the *Product* is 393024: 5 *Figures* cut off on the *left hand*, the *Comma* is 3 *Roods*, and the 5 laſt *Figures multiplyed* by 40, cut off 5 *Figures*, and the reſt will be 37 *Perch*.

15 : 16
15 : 16
90 96
1516
7580
1516

Acres 22|98256
4
Roods 3|93024
40
Perch 37|20960

By the Line of Numbers.

Extend the *Compaſſes* on the *line* of *Numbers* on the *Scale* of *Scales* from □ which is at 160 unto the *ſide* of the *Square* A B 15 *Ch*: 16 *Lin*. which is 60 *Perch* and above $\frac{1}{3}$, the ſame diſtance will reach from the ſame 60 $\frac{1}{3}$ *Perch*, to 22 *Acres*, 3 *Roods*, and 37 *Perch*, and the 20960 part of a *Perch*.

SECT. V.

How to Meaſure *a* Long Square *Piece of* Ground *by a* Chain *of* 20 Links *to a* Perch, *according to Mr.* Wing.

MAſter *Wing* in his *Art* of *Surveying*, in the 113 Page hath deſcribed a *Chain* of 20 *Links* in a *Perch*, which is ſomewhat more ready, if you will reckon the *Land* in *Perches* for ſmall parcels of *Land*.

Suppoſe a piece of *Land* be in *length* 36 *Perches* and 16 *Links*, and in the *breadth* 3 *Perches* 2 *Links*; By this *Chain* I deſire to know the *Contents* thereof, having 20 *Links* in a *Perch*, I deſire to perform the *operation* in a *Decimal* way; Count by half the number of *Links*, and then the *Sums* will ſtand thus; and cutting off 2 *Figures*, and you have for the *Contents* of the *piece* of *Ground* 114 *Perches* $\frac{8}{100}$ parts. But I would adviſe the Practitioner in greater parcels of *Land*, to follow Mr. *Gunter's Chain*, the *Surveyors* all generally making uſe of him; therefore, for further Uſe of Mr. *Wing's Chain*, I refer you to the Page of his Book of the *Art* of *Surveying*.

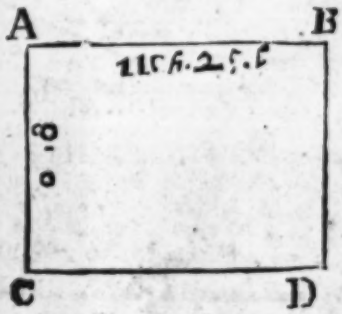
368
31
368
1104
114:08

SECT. VI.

To Meaſure *a* Long Square piece *of* Ground.

LEt the long *piece* of *Ground* be A B C D whoſe *length* A B is 11 *Chains* 25 *Links*, or 45 *Perch*, and his *breadth* A C 8 *Chains*, or 32 *Perches*.

Multiply one by the other, as before in the laſt *Example*, directed by Mr. *Gunter's Chain*; and you will find the *Contents* of the *Ground* to be 9 *Acres*, no *Roods*, but 0 *Perch*.



By

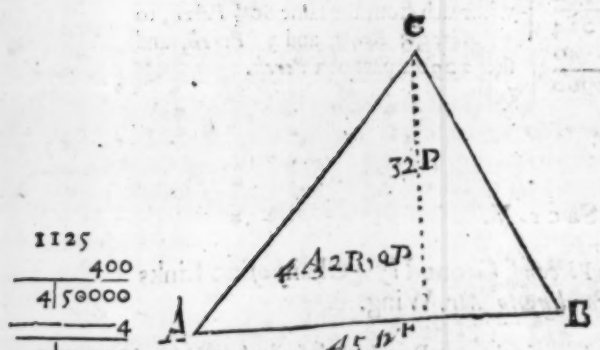
By the Line *of* Numbers.

1125
800
9|00000

Extend the *Compaſſes* from the □ *Center*, which is at 160 *Perch* unto the *length* AB 45, and the ſame *diſtance* will reach from the *breadth* AC 32 *Perch*, to 9 *Acres*.

SECT. VII.

To Meaſure *a* Triangular Piece *of* Ground.



1125
400
4|50000
4
2|00000
4 *Acr.* 2 *Ro.*

SUppoſe the *Baſe* of a *Triangular* piece of *Ground* A B whoſe *meaſure* is 11 *Chains* 25 *Links*, or 45 *Perch*, and the *perpendicular* C D 32 *Perch*, or 8 *Chains*; Take the half thereof, and *Multiply* one in the other, will produce the *Contents* of the whole *Triangle* to be 4 *Acres*, 2 *Roods*, 0 *Perch*.

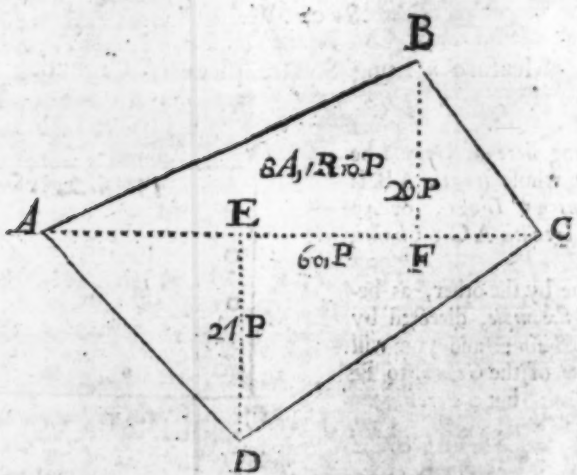
By the Line *of* Numbers.

Extend the *Compaſſes* from the Δ *Center*, which is at 320 — unto the *Baſe* A B — 45, the ſame extent will reach from the *perpendicular* C D 32 unto the quantity of *Acres*, which is 4 *A.* ½ as before.

SECT. VIII.

To Meaſure *a* piece *of* Ground *of Four unequal* ſides *called a* Trapezia.

LEt the *Ground* given be A, B, C, D; after you have taken the *Angles* with your *Compaſs*, and noted them down in a piece of Paper or *Field-Book*, (as ſhall be ſhewn in the following Diſcourſe) You muſt Protract or lay down the *Figure* as I do this, by a *Scale* of equal parts of 10, or 15, or 20, or 25, or 30 *parts* divided



into

into an *Inch*; I have laid down all the following by 20 *parts* or *Perch* in an *Inch*: then draw the *Diagonal Line* A C, and with your *Compaſſes* take the diſtance A C, and apply it to your *Scale* of 20 *Perch* to an *Inch*; and you will find it 60 *Perch*, or 15 *Chain*; and then if you let fall the *perpendiculars* B F and D E, and *meaſure* them in the like manner, you will find by your *Scale* B F 20 *Perch* or 5 *Chain*, and D E 24 *Perch*, or 6 *Chain*.

In reſpect the *Baſe* is common to both the *Triangles*: You may therefore add the two *perpendiculars* together 20, and 24, the ſum will be 44, the half thereof is 22 *Perch*. This *Number* being *multiplyed* by the whole *length* of the *Common Baſe* A C, 60 *Perch*, giveth 1320 *Perch*, that *divided* by 160, gives the *Contents* of the *Trapezia* or *piece* of *Ground* to be 8 *Acres*, 1 *Rood*, 0 *Perch*. You might have *multiplyed* half the *Baſe* A C 30 by the ſum of the two *perpendiculars* 44, and it gives you the ſame as before.

60
22
120
120
1320

5 (4)
132(0)(8
160(0)
44
30
1320

By the Line *of* Numbers.

Extend the *Compaſſes* from the *Trine* △ *Center* at 320
to half the *length* of the *Diagonal* A C ——— 30

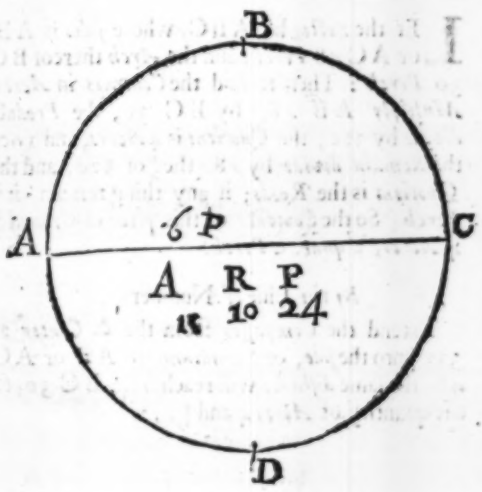
The ſame will reach from the *Sum* of the *perpendicular* 44, to the quantity of *Acres*, which is 8 $\frac{25}{160}$ *Acres*.

After this manner you may *meaſure* a *piece* of *Ground* of 5—6—7—8, or any *number* of *Sides*, by bringing it into *Triangles* and *Trapezias*, as ſhall be ſhewn.

SECT. IX.

To Meaſure *a* Piece *of* Ground *which is a perfect* Circle.

THE proportion of the *Circumference* of any *Circle*, to its *Diameter*, is as 7 to 22. *Example.* In this *Circle* A B C D let the *Diameter* thereof be 56 *Perches*, *Feet*, or *Inches*, which *multiplyed* in it ſelf giveth 4136. This *Number multiplyed* by 11, gives 45496, which being *divided* by 14, the *Quotient* will be 3249 $\frac{10}{14}$, that is the *Area* of the *Circle*.



How many *Poles* and *Feet*, or *ſquare Inches*, is in any *Circle* whatſoever, you may know better by theſe *Rules*; Firſt, If you know the *Diameter*, and would find the *Circumference*, ſay, as 7 to 22, ſo the *Diameter* 56 to the *Circumference* 176; Or if you know the *Circumference*, and would find the *Diameter*, ſay, as 22 to 7, ſo is the *Circumference* 176, to the *Diameter* 56.

(2)
6(4)(1
4(0)

Acres as
5:1:24 Per.

7:22:56
22
112
112
1232

54
xxxx[176
777
22:7:176
7
1232

xx
zz
xxxx(56
zzz
z

The Diameter *and* Circumference *being thus known, the* Rule *to find the* Content *is this.*

The *Diameter* being 56 *Perch*, and the *Compaſs* 176, the half of both theſe *multiplyed* together, and *divided* by 160, you have the quantity of *Acres* 15, *Roods* 1, *Perch* 24, which is the *Contents* of that *Circle*.

88
28
704
176
2464

By the Line *of* Numbers.

Extend the *Compaſſes* from *O Center* at (203 $\frac{7}{11}$ unto the *Diameter* A C 56, the ſame diſtance will reach again from 56 to the quantity of *Acres* 15 $\frac{4}{10}$.

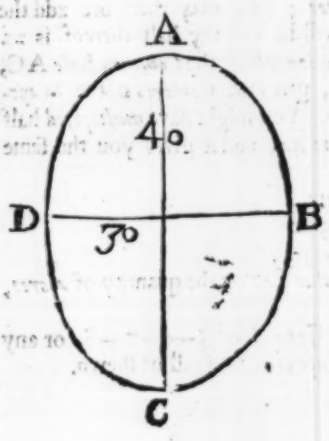
3
x86
x46(4(15
x66(0(

I confeſs though the ordinary proportion of 7 to 22, is ſomewhat too much; yet it is but about 1 in 3000, which will breed no great difference in theſe Queſtions.

SECT. X.

To Measure *a* Ground *being a true* Oval.

Multiply 40
one by the 30
other. 00
120
Multi- 1200
ply by 491
1200
10800
4800
A. 5 589200
4
R. 3 5 6800
40
Per. 22] 72000



IN the *Oval* ABCD, let the *length* be given 40 *Perch*, or *Feet*, or *Inches*; and DB 30 of the ſame *meaſure*: Then to find the *Quantity* in *Perch*, *Feet* or *Inches*; if you work by the ſame Denomination of *Feet* and *Inches*, as I do of *Perches*.

Multiply AC by DC 30, the *Product Multiply* by 491, and from that *Product* cut off 5 *Figures* as before directed, and as in the Margin, the *Contents* will be 5 *Acres*, 3 *Roods*, 22 *Perch*, $\frac{72}{100}$ *parts* of a *Perch*.

By the Line *of* Numbers.

Extend the *Compaſſes* from the 0 *Center* in the *Line* at 203 $\frac{7}{10}$ to the *length* of the *Oval* AC 40, the ſame *diſtance* will reach from the *breadth* DB 30 unto the *Contents* in *Acres*, 5 *Acres* $\frac{7}{10}$ *fere*.

SECT. XI.

To Meaſure *a* piece *of* Ground *lying in form of a* Sector *of a* Circle.

Mult. 48
30
00
144
1440
Divided by 320
(1)
2(6)
320)1440(4
320
160(0(2 *qu.*
0



LEt the *Sector* be ABC, whoſe *ſides* is AB, or AC 48 *Perch*, and the *Arch* thereof BC 30 *Perch*: Then to find the *Contents* in *Acres*, *Multiply* AB 48, by BC 30, the *Product divide* by 320, the *Quotient* is 4 *Acres*, and 160, the *Remain divide* by 180 the $\frac{1}{2}$ of 320, and the *Quotient* is the *Roods*; if any thing remain, it is *Perch*; So the *Contents* of this *piece* of *Ground* is 4 *Acres*, 2 *quar.* 0 *Perch*.

By the Line *of* Numbers.

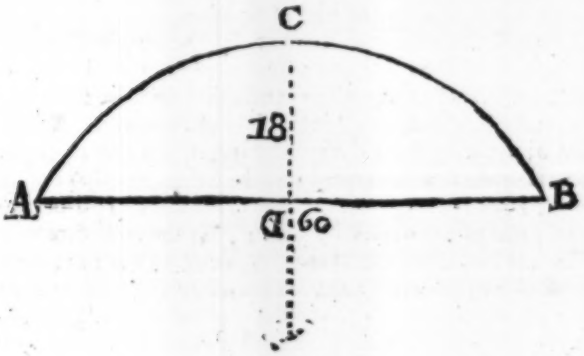
Extend the *Compaſſes* from the Δ *Center* at 320 unto the *ſide*, or *Semidiameter* AB or AC 48, the ſame *diſtance* will reach from BC 30, to the quantity of *Acres* 4 and $\frac{1}{10}$.

SECT. XII.

To Meaſure *a* piece *of* Ground *that is a* Segment, *or part of a* Circle.

LEt the *Segment* be ABC; AB 60 *Perch*, DC 18 *Perch*: *Multiply* the *Chord* of the *Segment* 60 by the *perpendicular Height*, and the *Product divide* by 225 the *Gage-Number*, and the *Quotient* will be the *Acres*, the *Remain divide by* 40 and it is found 4 *Acres*, 3 *Roods*, 8 *Perch*, the quantity of *Ground* in the *Segment*,

60
18
480
60
1080
(1)(8)
xø (o)
xø8ø(4 A.
xxy
3(2)
x8ø(3 R.
y6
10
2
—P.
8 A.R.P.
4:3:8



By the Line *of* Numbers.

Extend the *Compaſſes* always from 225 unto the *Chord* of the *Segment* AB 60: the ſame *diſtance* will reach always from the *perpendicular Height*, unto the quantity of *Acres* 4 and $\frac{3}{10}$ *fere*.

SECT. XIII.

Having a Plot *of* Ground *with the* Content *in* Acres, *To find how many* Perch *of that* Scale *was contained in one* Inch, *whereby it was* Plotted.

LEt the long *Square piece* of *Ground*, be containing 9 *Acres*; Firſt, *Meaſure* the *Plott* by a known *Scale*, which ſuppoſe it be of 10 *Perch* in an *Inch*; ſo *meaſuring* AB, you find it 22 $\frac{1}{10}$ *Perch*; alſo the *breadth* 16 *Perch*.



By the Line *of* Numbers.

If you work by the *Rule* of the laſt *Square Plott*, you will find the *Contents* 2 $\frac{21}{100}$ *Acres*. Now on the *Line* of *Numbers*, take with your *Compaſſes* the *diſtance* between 2 $\frac{21}{100}$ and 9 *Acres*, the half *diſtance* thereof will reach from 10 on the *Line* of *Numbers* unto 20: ſo I conclude the *Ground* was caſt up by a *Scale* of 20 *Perch* in an *Inch*.

$$\left\{\frac{9 \times 109}{2\frac{1}{4}} = 20\right\}$$ By *Arithmetick*.

Sect. XIV.

A Piece *of* Ground *being* measured *by the* Statute-Perch *of* 16½ Feet, *To know how many* Acres *it is*, *it being* measured *by a* Perch *of* 21 Foot, *which is the* Irish Perch.

Sta. Per: 16½ *Ir.* 33 | 11 *Foot.*
Per. 33

21
42
x²
42z | 14
33

The *Squre* of 11 is 121.
and of 14: 196
196: 121: 1440
121
1440
2888
1440
x | 174249

zgz(1)
xg7
z7z4(9)
9z46(2)
x74z40 | 888, 192/196
xg666
xgg
x

Example. The last *Piece* of *Square Ground* being found 9 *Acres* by the *Statute-Perch* of 16½ *Foot*; and you would know how many it is by the *Irish Perch* of 21 *Foot*.

By the Line *of* Numbers.

Extend the *Compasses* from the *Irish-Perch* of 21 *Foot*, to the *English Statute-Perch* of 16½ *Foot*, the same *distance* will reach from 9 *Acres* turned twice over unto 5 6/16 *Acre*, *fere*: Or in the *Scale* of *Reduction* extend the *Compasses* from 16½ *Foot* to 21, the same *distance* will reach from 9 to 5/8 in the *Line* of *Numbers*. And so of any other *measure*. Now by *reducing* the 9 *Acres* into *Perches*, it makes 1440 *Perch*; and because the greater *measure* is to be *reduced* into the lesser, *Multiply* the *given Quantity* 1440 by 121 the *Square* of 11, which 11 was found, thus. 16½ being a *Fraction*, it *reduced* into *halfs*, makes 33 *divided* by 3 is 11; So the *Irish-Perch* 21 *Foot* in *halfs* is 42 *divided* by 3 is 14, those two *Numbers squared* a 11 is 121, the *Square* of 14 is 196, the *Product* of two *Numbers* 1440 *multiplyed* by 121, the *Product* is 174240: that *divide* by 196, the *Square* of 14, and the *Quotient* is 888 96/196 *Perch*, *reduced* into *Acres*, is 5 *Acres*, 5 *Roods*, 8 *Perch* 96/196, almost 9 *Perch* according to the *Irish-measure*.

Suppose you had been to *Reduce Irish-measure* into *Statute-measure*; then *multiply* 1440 by 196, and the *Product* would have been 282240: that *divided* by 121; and the *Product* had been 2332 8/11 *Perches fere*, which makes *Acres* 14, *Roods* 2, *Perch* 12 8/11 *fere*, *Statute-measure*.

By the Line *of* Numbers.

3(8)
88 | 8 | 5
x6 | 0
quar.
8(8(2—8 P.
40
5 *Ac.* 2 *Q.* 8 P.
Perch: 96/196
1440
196
8640
12960
1440
282240
282240
121 | 68
2332
121
7(9
zzz(2 (14
x660
x

Extend the *Compasses* in the *Scale* of *Reduction* from the *Number* of *Feet* in *Customary measure*, as I do from 21 *Foot* to the *Perch* of *Irish-measure*: the same will reach from 9 *Acres Irish* in the *Line* of *Numbers* to 14 *Acres*, 2 *Quarters*, and 12 *Perch Statute-measure*.

Or if you extend the *Compasses* from 21 in the *Line* of *Numbers* to 16 and ½, the extent turned twice over from 9, will fall upon 14 and ½ *Acres*, and a little more.

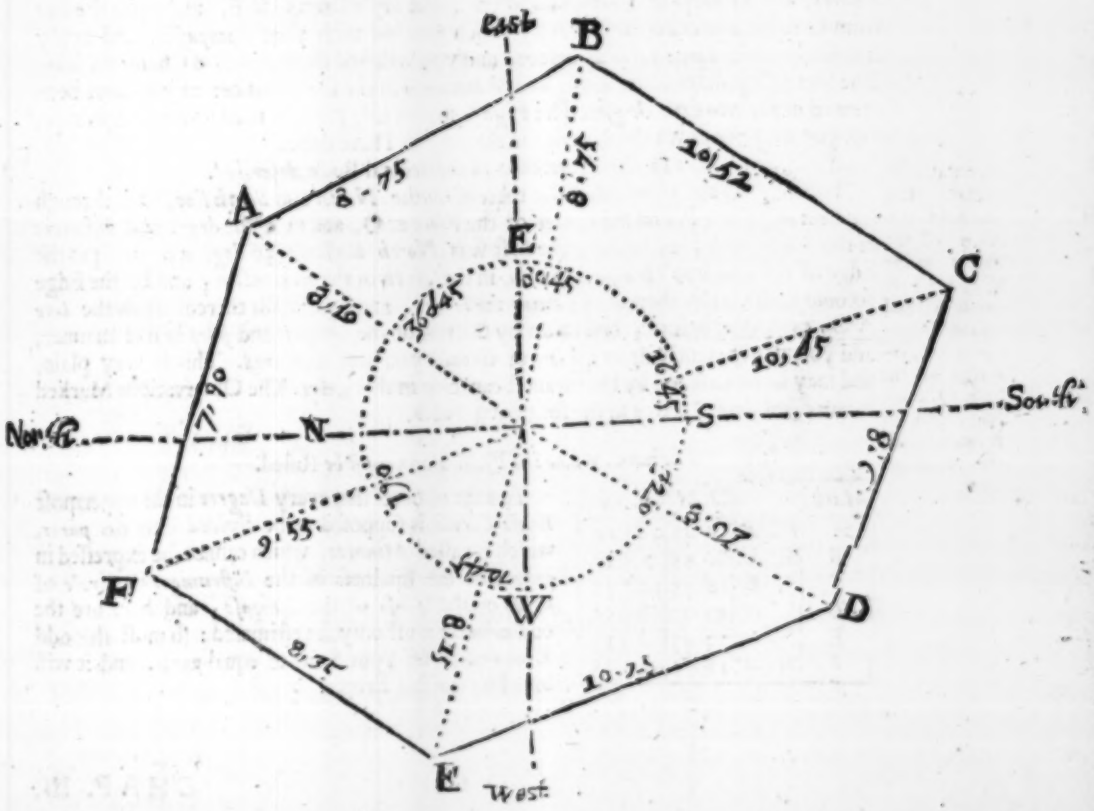
So that if you remember in all sorts of *measure* to *reduce* your *Fraction* into the same Denomination, and seek out the least proportionable terms: by *Dividing* by 3 if half *Foot*, and *squaring* these terms as before directed, you have a *Rule* that serves for all sorts of *Customary* or *Irish measure* whatsoever.

CHAP. II.

How to take the Plott *of a* Field *at one* Station *taken in the middle thereof by the* Azimuth-Compaſs.

BEfore you go into the *Field*, you muſt Rule a piece of Paper in 8 *Columns* as you ſee the *Figure* following in this *Chapter*, makes all plain, without any more Deſcription, which is called a *Field-Book*. Secondly, when you come into the *Field*, firſt place Marks at the ſeveral *Angles* of the *Field*, as at A B C D E F, in the following *Figure*; then make choice of ſome convenient place about the middle thereof at O, to fix your *Compaſs*, if you can ſee all the Marks; and be ſure the *Braſs-Diameter* and *Slits* before deſcribd, be ſet directly over the *Meridian* or *North* and *South Line* of the *Chard*, and there fixed.

This done, direct your *Sights* to your firſt Marks at A, Marking what *Degree* the *Index* cutteth, which let be 36 *Degr.* 45 *Min.* you may eſtimate the *Minutes*; This you muſt note down in your *Field-Book* in 1 and 2 *Column* thereof, as you ſee in the *Book* it is plain ſet down; then *meaſure* the *diſtance* from O the place of the *Compaſs* to A your firſt Mark, which let contain 8 *Chains*, 10 *Links*, which muſt be placed in th 3 and 4 *Column* of your *Field-Book*, as you ſee in the *Figure* of the *Book*.



Then direct your *Sights* to B the ſecond Mark, and note the *Degrees* cut by the *Index*, which let be *South Eaſterly* 80 *Degrees* 45 *Minutes*, and the *diſtance* 8 *Chains* 75 *Lin.* You muſt put down in the *Field-Book*, as before; Firſt, the Letter B; Secondly, the *Inclination* to the *Meridian* cut by the *Index South Eaſterly* 80 *Degr.* 45 *Min.* in the third *Column*; then 8 *Chains* 75 *Links* in the fourth, as you may ſee in the *Columns* in the *Book*, all plain; then direct your *Sights* to C your third Mark, and note the *Degrees* cut by the *Index*, which let be *S. E.* 16 *degr.* 45 *min.* and the *diſtance* O C 10 *Chains* 45 *Links*, put the ſame down in the *Field-Book* likewiſe, as before directed; then direct your *Sights* to D, and note the *Degrees* cut by the *Index*, which let be *S. W.* 32 *degr.* 00 *min.* the *diſtance* O D, 8 *Chains* 53 *Links*, Note it down in the *Book*, as before.

Then direct your *Sights* to E, the *Index* cutting 72 *degr.* 45 *min. North Weſterly*; and the *diſtance* O E 8 *Chains* 15 *Links*: They muſt be noted in the *Book* as the reſt are.

Laſtly, direct your *Sights* to F your laſt Mark, the Edge of the *Index* cutting in the upper *Braſs Circle N. W.* 18 *degr.* 00 *min.* the *diſtance* O F 9 *Chains* 55 *Links*; then will the Obſervation ſtand in the *Field-Book* as in the following *Table* or *Figure*; then by a *line* of *Chords*, or by the *Protractor* you may preſently *Protract* the exact *Figure* of the *Field* upon Paper thus, By a *line* of *Chords*; take 60 *degr.* and draw the *Circle*. Secondly, draw the *Meridian line* of *North* and *South*, and *parallel-line* of *Eaſt* and *Weſt*. Thirdly, your firſt Obſervation and *degr.* cut by the *Index*, was 36 *degr.* 45 *min. N. E.* Therefore take 36 *degr.* 45 *min.* off the *line* of *Chords*, and lay from the *Meridian line* M to N. Fourthly, the *diſtance* O A was found 8 *Chains* 10 *Links*; take with your *Compaſſes* off any *Scale* of equal *parts*, 8 *Chains* and $\frac{1}{10}$ that ſtands for 8 *Chains* 10 *Links*; lay this *diſtance* from O to A, and draw the *prick'd line* O A.

Then ſecondly, take out of the *line* of *Chords* the ſecond *Angle S. E.* 80 *degr.* 45 *min.* and lay from the *South* towards the *Eaſt* on the *blind-Arch*, and through it draw the *line* O B; then take off the ſame *Scale* of equal *parts* 8 *Chains* 75 *Links*, that is, 8 *parts*, and 75 *parts* of 1 *divided* into 100, and lay it from O to B, and prick the *line* from O to B, and draw the *line* A B, which *meaſure* with your *Compaſſes*, and apply it to the *Scale* of *equal parts* as before, and you will find the *ſide* A B 8 *Chains* 75 *Lin.* The like do by all the other *Angles* and *diſtances* in the ſame manner as you have been ſhewed in the two firſt *Angles*. The *Figure* makes it ſo plain, it need no further precept; and you may put down the *Number* in the *ſide*, as I have done.

Now by the Protractor *in the* Second Book *deſcribed.*

Turn the *Protractor* after you have laid down all the *Angles* in the *N E.* and *S. E. quarterly*, and lay the *Center-Pin* of the *Protractor* on the *Point* O, as before; and the *Diameter* on the *Meridian-line*

You may lay the *Diameter*-Edge thereof on the *North* and *South line*, and through the *Center*, put a *Pin* on the *Center* of the *Plott* at O, and note the *degr.* and *diſtances* in the *Field-Book*, as before: the firſt was *North Eaſterly* 36 *deg.* 45 *min.* put the Edge of the *Index* to 36 *degr.* 45 *min.* in the *Arch* of the *Protractor*; and by the Edge account in the *Scale* thereof 8 *Chains* 10 *Links*; and by the *ſide* thereof draw the *line* A O, prick'd as before; and ſo do by the reſt of the *Angles* and *ſides* in like manner, and you may preſently draw a *Plott* of *Ground* you have *meaſured*. This is very plain, and may be underſtood by the meaneſt capacity in this *Art*. The Obſervations Marked in the *Field Book* ſtand as in the following *Table*.

The manner how the Field Book *muſt be* Ruled.

Mark.		*D.*	*M.*	*Ch.*	*Lin.*
A	*N. E.*	36	45	08	10
B	*S. E.*	80	45	8	75
C	*S. E.*	16	45	10	45
D	*S. W.*	32	00	8	53
E	*N. W.*	72	45	8	15
F	*N. W.*	18	00	9	55

You are to note, that every *Degree* in the uppermoſt *Braſs-Circle* is ſuppoſed to be *divided* into 60 *parts*, which is called *Minutes*, which cannot be expreſſed in regard of the ſmalneſs of the *Inſtrument* or *Circle* of *Braſs* on the *Glaſs* of the *Compaſs*; and therefore the odd *minutes* muſt only be eſtimated: ſo muſt the odd *Links* taken off your *Scale* of equal *parts*, and it will breed no ſenſible Errour.

CHAP. III.

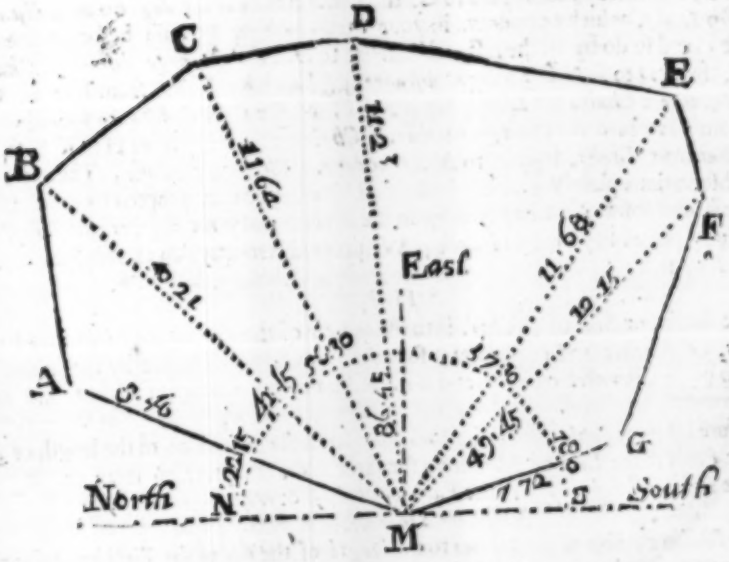
CHAP. III.

How to take the Plott *of a* Field *at one Station taken in any* Angle *thereof, by the* Sea-Compaſs.

IN the *Figure* of the *Field* following, place your *Compaſs* at M, ſet your *Braſs-Diameter* right over the *North* and *South points* or *Line*; then firſt direct your *Sights* to A, which let be ſuppoſed to be 22 *degr.* 15 *min. N. E.* which Note in your *Field-Book*, as before; then *meaſuring* the *diſtance* with your *Chain* M A which let be 8 *Chains* 46 *Links*, which place in your *Field-Book* according to former directions.

Secondly, Direct your *Sights* to B, the *degrees* cut off by the *Index*, ſuppoſe 42 *degr.* 45 *min.* and ſuppoſe the *diſtance meaſured* to be M B 10 *Chains* 21 *Links*, and put them down alſo in the *Field-Book*.

Thirdly, Direct your *Sights* to C, the *degr.* cut is 66 *degr.* 30 *min.* and the *diſtance* M C 11 *Chains* 64 *Links*, put theſe in your *Field-Book* alſo, as before; and in the ſame manner you muſt deal with the other *marks* D M, and E M, and M F, and M G; and ſo having them all in the *Field-Book*, they will ſtand as followeth.



The Figure *of the* Field-Book.

M		Deg.	Min.	C.	L.	North.	South.	East.	West.
A	NE	22	15	8	46				
B	NE	42	45	10	21				
C	NE	66	30	11	64				
D	NE	86	45	11	23				
E	SE	57	30	11	68				
F	SE	49	45	10	15				
G	SE	18	00	7	72				

Chap. IV.

How to Measure *any* Piece *of* Ground *be it never ſo* Irregular; *And how to* reduce *the* Sides *into* Triangles *or* Trapezias, *and to caſt up the* Content *thereof in* Acres *and* Perches.

SUppoſe you were to *Meaſure* a *Piece* of *Ground*, or *Wood*, or *Marſh*, or any place whatſoever, by your *Compaſs* and a *Line* marked as the 4 *Pole-Chain* before deſcribed in the firſt *Chapter*; and if you cannot ſee all the *Angles* by reaſon of the bigneſs thereof, then you muſt *meaſure* round about by the *ſides* thereof, as in this *Figure* following; and the Obſervations made in the *Field* are ſet down in the *Field-Book* following, ſo plain, that it need no further precept.

Suppoſe you made your firſt Obſervation at A in the *Field* in the following *Figure*, (the *Compaſs* being rectifyed as before directed) you direct your *Sights* along the hedge to the *Mark* in the corner at B, and the *Index* cutts 54 *degr.* from the *South Weſtwards*, and the *diſtance* is 5 *Chain* 12 *Links*, which ſet down in your *Field-Book* thus, A B bears *S W* 54 *degr.* 00 *min. diſtance* 5 *Chain* 12 *Links*; Then make your ſecond *Station* at B, and direct your *Sights* to C, the *Index* cuts *N W* 45 *deg.* 00 *min. diſtance* 2 *Chain* 89 *Links*, which note down in your *Field-Book*, as you did before in the ſecond place; and ſo do by all the reſt. From C to D *N W* 76 *degr. diſtance* 3 *Chains* 35 *Links*, from D to E *N E* 31 *degr. diſtance* 4 *Chains* 55 *Links*, from E to F *N E* 56 *degr. diſtance* 2 *Chains* 57 *Links*, from F to G *N E* 21 *degr. diſtance* 2 *Chains* 24 *Links*, from G to H *S E* 51 *degr.* 00 *min.* 2 *Chains* 95 *Links*, from H to K *S E* 34 *degr.* 3 *Chains* 25 *Links*, from K to A *S W* 4 *degr.* 2 *Chains* 95 *Links*; Thus you ſee all the Obſervations plainly ſet down in the *Field-Book*, you may proceed to *Protracting* your places of Obſervation and *Marks* in the *Field*, and your *degrees* and *length* of *Lines* orderly placed in your *Field-Book*; We proceed two ways to examine the truth: Thus the *Rule* is.

How to know if the *Sides* be rightly *meaſured* before you go out of the *Field*, and *Protract* the *Platform* thereof.

Firſt,

As the *Radius* or *Sine* of 90 *degr.* is to the *length* of the *ſide* of the *Field* in *Chains* and *Links*, or *Perches* and 100 *parts*; ſo is the *Sine* of the *degree* cut by the *Index* to the *length* of the *Parallel* of *Eaſt* and *Weſt* in *Chains* and *Links*, or *Perches* and 100 *parts*.

Therefore by your *Scale* extend the *Compaſſes* from the *Sine* of 90 to the length of the *ſide* of the *Field* in the *Line* of *Numbers*, the ſame *diſtance* will reach from the *degrees* cut by the *Index* to the *length* in the *Parallel* of *Eaſt* or *Weſt*.

Secondly,

As the *Radius* or *Sine* of 90 *degrees* to the *length* of the *ſide* of the *Field* in *Chains* and *Links*: or *Perch* and 100 *parts*; ſo is the *Complement Sine* of the *degrees* cut by the *Index* to the *length* of the *Meridian* of *North* or *South* in *Chains*, or *Links*, or *Perch*, or 100 *parts*.

Wherefore Extend the *Compaſſes* from the *Sine* of 90 *degrees* to the *length* of the *ſide* of the *Field* in the *line* of *Numbers*; the ſame *diſtance* will reach from the *Sine Complement* of *degrees* cut by the *Index* to the *length* of *North* or *South* in the *Meridian*.

So that you ſee the 4 laſt *Columns* in the *Field-Book* are noted *North* and *South*, *Eaſt* and *Weſt*.

Now to know by the *Chains* and *Links*, the firſt Obſervation from A to B, is *S W* 54 *degr.* and the *diſtance* A B is 5 *Chains* 12 *Links*; therefore by the laſt *Rule* extend the *Compaſſes* from 90 *degr.* to 5 *Chains* 12 *Links* in the *Line* of *Numbers*, that *diſtance*

will

will reach from 54 *degr.* cut by the *Index* to 4 *Chains* 14 *Links* in the *line* of *Numbers*, which is the *distance* in the *Parallel* of *West*, and also the same extent will reach from the *Complement* of 54 *degr.* which is 36 *degr.* to 2 *chains* 97 *links* in the *line* of *Numbers*, which is the *distance* in the *Meridian South*, and put it in the *South Column* of your *Field-Book*, as you did 4 *chains* 14 *links* in the *Column* of *West*; and so you may do with the rest of the Observations.

But the most sure way and least Errour, is, to convert your *chain* and *links* into *Perches* and 100 *parts* of a *Perch*, and then you can *Protract* in *Perch* and 100 *parts* the better.

Thus if you *Multiply* the *number* of *chains* found in the *side* by 4, by reason 4 *Perches* are in every *chain*; and if there be above 25 *links* in the place of *links*, *divide* by 25, and the *Quotient* will shew the odd *Perch* to be added; and what remains is *links*: that *Multiply* by 4 likewise, the *Product* will be 100 *parts* of a *Perch*.

As for Example.

The first *side* A B his *distance* is 5 *chains* 12 *links*, *multiplyed* by 4, makes 20 *Perch*, $\frac{48}{100}$ *parts*, which put in the next *Column* to it; Now if you extend the *Compasses* from 90 *degr.* to 20 *Perch* $\frac{48}{100}$ *parts*, the same *distance* will reach from the *Sine* of 54 *degr.* cut by the *Index* to 16 *Perch* 56 *parts*, which is in the *West Column*, and the same extent will reach from the *Complement* 54 *degr.* which is 36 *degr.* to 11 *Perch* — 88 *parts*, which I put in the *South Column*; and by the same *Rule* I work in like manner by the rest of the Observations. The second *side* B C is 2 *chains* 89 *links*, *reduced* as before, makes 11 *Perch* $\frac{56}{100}$ *parts*; and so work by them, as before directed, you shall have all your *Numbers* stand as in the following *Figure* of the *Field-Book*.

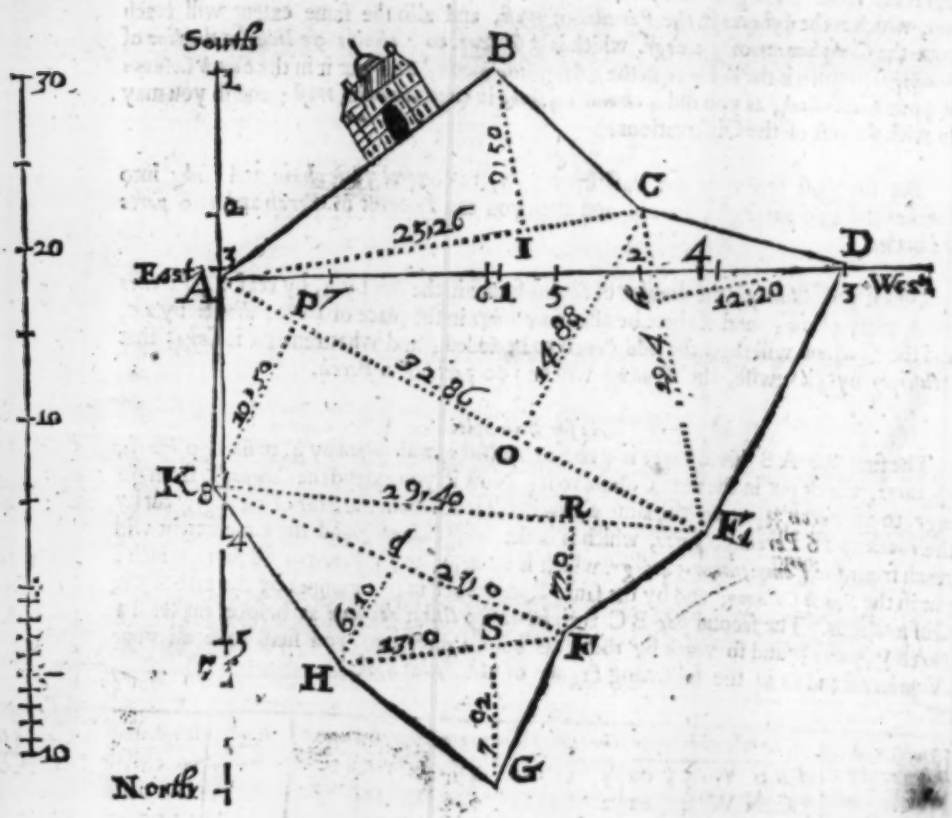
5 : 12
4 : 4
20 : 48

(1
2(4
2 — 89(3
4 23
8

3 *P.* - *pts.*
11 — 56
100

Houses name.	*Angle with Merid.*	*Cha. Lin.*	*Pol. 100 pts.*	*North.*	*South.*	*East.*	*West.*	
	A B S W 54 00	5 12	20 48	*P. pts.* 11 88			16 56	1
	B C N W 45 00	2 89	11 56	8 16			8 16	2
	G D N W 76 00	3 35	13 40	3 32			13 00	3
	D E N E 31 00	4 55	18 20	15 72		09 40		4
	E F N E 56 00	2 67	10 88	6 00		8 88		5
	F G N E 21 00	2 24	8 96	8 40		3 20		6
	G H S E 51 00	2 95	11 80		7 32	9 20		7
	H K S E 34 00	3 25	13 00		10 72	7 28		8
	K A S W 4 00	2 95	11 80		11 68		0 24	9
			The Sum	41 60	41 60	37 96	37 96	

Under the *line* are the *distances* in the *East Column*; and likewise the *Figures* on the inside the *Meridian*, are the *points* of *North*, as 1, 2, 3, 4, 5, 6 *Column*; and the *Figures* on the outside are 7, 8 to A, and are taken out of the *South Column*, and working as directed in the two first *sides*, you may find all the rest. The *Figure* makes all plain to the meanest Capacity; and so you will have the true *Plott* of your *Ground*, or *Park*, or *Wood-land*, or *Plantation*, or *place* whatsoever, drawn on Paper or Parchment. Now if there be any Houses by the *hedge-side*, made a mark in your *Field-Book* in that *Angle*, and how many *Chains* or *Perch* from the place you observe, and by it insert it into your *Plott*.



As for Example.

How to draw the *Plott* by the *Protractor.*

There is a *Houſe* in the firſt *ſide* and *Angle* A B, *S W* 54 *degr.* about 2 *Chains* 42 *Links*, or 9 *Perch* 21 *parts*, and reckon 1 *Chain* 24 *Links*, or about 5 *Perch*; therefore put it down in your *Book*, with the Man's Name that ows the *Houſe*, as I have done, (*John Cooke*) or the like; and if any *Houſe*, *Church*, or *Caſtle*, be in the *middle*, take the *Angle* thereof from any *Point*, and *meaſure* the *diſtance*, and note it in your *Book*, and enter it into your *Plott*, as I have done this *Houſe*. By theſe *rules* you may compleatly take a whole *Pariſh*, *Plantation*, or *Iſland*: Now if you draw a *Plott* by the *Protractor* deſcribed in the *Book* of *Inſtruments*, You muſt rule your *Paper* or *Parchment* with an obſcure plummet *Merid. Lines*, and *Parallel Lines* about 1 *inch* and $\frac{1}{2}$ aſunder; and put the *Pin*, the *Center* and *Rivet* upon any *Point*, and turn the *ſide* of the *Protractor* on the *Meridians*, and look in the *Field-Book* for the *Angle*, and put the *Edge* of the *Index* to the *degrees*, and count the *Perch* on the *Index-ſide*, there make a Mark with your *Pin* for the ſecond place, and draw a *Line* from that place by the *Edge* of the *Ruler* to the *Centers* for the *ſide* of the *Hedge* or *Field*.

As for Example.

Suppoſe you were to draw the *ſide* A B in the *Plott* with your *Protractor*, lay the *Protractor* on the *out-ſide* of the *Meridian-Line*, and the *Diameter-Edge* thereof to the *Meridian-Line*; then in the oppoſite *Degree* and *Quarter* as in this *Example* is *N E*: I put the Foot of the *Index* to 54 *degrees*, and from the *Center*, the *Edge* points *S W* 54 *degr.* Number the *Chains*, or *Links*, or 20 *Perch* 42 *parts*, and from that *Number* to the *Center* draw a *Line* by the *Edge* thereof, and you have the *Side* A B; by this *Rule* you may gain all the reſt. There is no Man that underſtands any thing in theſe *Arts*, but knows readily how to *Plott* a *Field* by the *Rule* before-going without more Directions, for they will be all the ſame.

CHAP.

CHAP. V.

How to find the juſt Quantity *or* Content *of any* Piece *of* Ground *in any* Form.

WE have ſhewed in the fore-going Chap. how to *Meaſure* the *Geometrical Square*, the *Parallelogram*, the *Triangle*, *Trapezium*, the *Circle*, and the like. Now we will ſhew you how to caſt up the *Contents* thereof more fully. Suppoſe the fore-going *Figure* A, B, C, D, E, F, G, H, K, be a *Plott* drawn or *Protracted* by a *Scale* of 10 *Perch* in an *Inch*, and the exact *Contents* thereof is required. Now becauſe it is an *Angular Plott*, neither in the form of a *Square*, *Parallelogram*, *Trapezium*, nor *Triangle*; therefore all ſuch *Plotts* muſt be reduced into ſome of theſe forms: which to effect, I *reduce* the main Body of the *Field* into the *Trapezium* ACEK, and the *reſidue* of it into 5 *Triangles*, as ABC, and CDE, and EFK, FHK, and FGH.

Now to know the juſt Quantity of *Acres*, *Roods*, and *Perches* the *Field* contains, I firſt *meaſure* the *Trapezium* ACEK, I *meaſure* with my *Compaſſes* the *length* of the *perpendicular* CO, and apply it to my *Scale* of 10 *Perch* in an *Inch*, and find it 14 *Perch*, $\frac{25}{100}$ *parts*; and likewiſe the *perpendicular* KP, and find it 10 *Perches*, 50 *parts*, which I add together, and they make 25 *Perches* 38 *parts*, which I *Multiply* in half the *Baſe* AE 16:43, and the *Product* is 416:99:34: Therefore if you cut off 4 *Figures* to the *right-hand*, you will have the *Contents* of the *Trapezium* 416 *Perch*, and cut off 2 *Figures* of the 4, and before the *Comma* is 99 *parts* of 100 of a *Perch* and $\frac{34}{100}$ *remains*, which is not to be taken notice of.

In like manner for the *Triangle* ABC, I *multiply* half the *perpendicular*: 4:75 by the whole *Baſe* 25 *Perch* 26 *parts*, or the whole *perpendicular* by half the *Baſe*, as before; it is all one, and the *Product* is the *Content* of the *Triangle* ABC 119 *Perch* 98 *parts*: and ſo likewiſe for the *Triangle* CDE, *multiply* half the *baſe* 9 *Perch* 52 by 12 *Perch*, and 10 DY the *perpendicular*, and the *Product* is 116 *Perch* 14: is the *Contents* of that *Triangle*. Likewiſe in the *Triangle* EFK, the *length* of the *perpendicular* FR is 7 *Perch*: 00 and the half *length* of the *baſe* EK is 14 *Perch* 70, *multiplyed* as one whole *Number*, the *Product* is 102 *Perch* 90 *parts* 00: the *Contents* of that *Triangle* EFK: the 4 *Triangle* FHK *perpendicular*: 6 *P.* 10: H*q* *baſe* FK 11 *P.* 50 the *Contents* is 70 *Perch*: 15: the firſt *Triangle* FGH the *perpendicular* GS is 7 *P.* 92 and the *baſe* FH, the half thereof is 6 *P.* 50: *multiplyed* together, and the *Product* is 51 *P.* 48 *parts* for the *Triangle* FGH.

Laſtly, I add the ſeveral ſums together, and they give the *Content* of the whole *Figure* in *Perches* and 100 *parts*.

The *Area* or *Content* of the

1 *Trapezium*	ACEK	416:99
2 *Triangle*	ABC	119:98
3 The *Triangle*	CDE	116:14
4 *Triangle*	EFK	102:90
5 *Triangle*	FHK	70:15
6 *Triangle*	FGH	51:48

The *Area* or *Content* of the whole *Field* or *Wood* is 877 *P.* 64

Reduce Perches *into* Acres, Roods, *and* Perches.

Which if you will *reduce* into *Acres*, *Roods* and *Perches*, you muſt note, that 16 *Foot* and $\frac{1}{2}$ *Square* is a *Perch*, and 160 of theſe *Perches* makes an *Acre*; therefore *Divide* 877 *Perch* by 160, the *Quotient* ſhews the *Acres* to be 5; that which *remains* above 40 *divide* by 40, and the *Quotient* will be *Roods* 1: and that which *remains* will be 37 *Perch*. This is a General Rule for *reducing* of *Perches*; ſo that the whole *Plott* of *Ground* yieldeth the *Content* of the ſaid *Field* 5 *Acres*, 1 *Rood*, 37 *Perch* and $\frac{44}{160}$ of a *Perch*.

This is the way to caſt up the *Content* of any *Irregular Field*, by *reducing* it into *Trapeziums* and *Triangles*, and *adding* their ſeveral *Products* into one *Sum*, which ought heedfully to be regarded, it being one of the moſt material works belonging to the Practice of a *Surveyor*; for unleſs he be perfect herein, he can never perform any Work of that nature aright. I have been brief and plain in ſhewing the *Art* of *Surveying* by the *Sea Compaſs*; I might have been longer, but to avoid Prolixity, I think what is right is ſufficient: If any deſire a larger Diſcourſe, he may make uſe of Mr. *Leybourn's Compleat Surveyor*, or Mr. *Wing's Art* of *Surveying*, and others that have writ at large of the Uſe of the *Plain Table*, which is the moſt eaſy and uſeful *Inſtrument* in the *Art* of *Surveying* of ſmall *Incloſures*. But the *Compaſs* fitted as before, will with a little labour do any thing as exact as the *Plain Table*, *Theodolite*, *Circumferentor*, *Protractor*, or any other *Inſtrument*; eſpecially large places, as *Woods*, *Parks*, *Forreſts*, or *Plantations* or the like: and what Direction I have given in Uſe of the *Sea-Compaſs* will ſerve for an Introduction to all other ſorts of *Inſtruments* for *Surveying* of *Land*.

CHAP. V.

How to take the Height *of any* Iſland, *or* Mountain *in the* Sea *by an Example made by the* Author *of the* Height *of* Tenariff.

MAny Learned Men have writt of the Great Incredible Height of ſeveral *Mountainous Hills* and *Iſlands* in the World. For taking of the *Height* of *Iſlands* in the *Sea*, none have greater opportunities than *Sea-men*. By them may all Men be informed of the truth of ſuch like things; and alſo of ſeveral good *Stars* that be to the *Southward*, as the *Croſiers* and *Cannobas* in the *Stern* of the *Ship*, and any other, did they but obſerve any ſuch *Stars* from a known *Latitude*, and take their *Meridian-Altitude* and time of *Night*; or if they cannot, or will not *Calculate*, and find by it the *Stars Altitude*, and *Longitude*, and *Declination*: yet if they bring it home, and give it to ſome able Artiſt, he will do it, and all Men ſhall have the benefit of it, and by it, it would be a great help to *Navigators*.

It is reported of *Ariſtotle*, *Mela*, *Pliny*, and *Solinus* of the Invincible *Height* of *Athos* a Hill in *Macedonia*, and of *Caucaſus*; and of *Caſſius* in *Syria*, and many other places: and among the reſt one of the moſt miraculous things which they have obſerved of the Mountain *Athos*, is, that it being a *Hill* and *Mountain* ſituated in *Macedonia*, it caſts a ſhadow into the *Market-place* in *Myrrhina*, a Town in the Iſland *Lemnos*, diſtant from *Athos* 86 Miles to the *Eaſtward*. It is no marvel it caſt ſo large a ſhadow, ſeeing by Experience of the ſhadow of a Mans Body, we find it extraordinary long at *Sun-Riſing*, as well as at *Sun-Setting*. They report it is Higher than the Region of the *Air*. *Julius Scaliger* writes from other Mens Relations, that the Iſland

Island *Pico* of *Tenariff* riseth in height 15 Leagues, or 60 Miles: Most Writers agree that it is the highest Mountain in the World, not excepting the Mountain *Slotus*; it self, which I question whether any mortal Man ever see *Slotus*, besides the *Monk* of *Oxford*, who by his skill in Magick conveyed himself into the utmost parts of the World, and took a view of all places about the *Pole*: yet that this Island cannot be so high, shall appear by the following Demonstration and Observation made by Me; all *Sea-men* that have used to *Sail* to the *Canaries* know, that the Snow is not off it above 2 Months in a Year, that is, *June* and *July*.

Patricius not content with the former Measure of 60 Mile high, reaches to 70 Mile high; Now that any Snow is generated 60 or 70 Mile above the plain *superficies* of the Earth and Water, is more then ever they can perswade any Men that understand these things, seeing that the highest Vapours never arise by *Ptolomy* 41 Miles, and by *Eratosthenes*'s Measure 48 Miles above the Earth; that is, There is never no Rain, Dew, Hail, Snow, or Wind, but still a clear serenity.

I have been and passed by *Tenariff* several times my self, in the Year 1652 I was there in the *Castle-Frigot* of *London* Cap. *John Wall* Mr. and Loaded our *Ship* at *Garrachica* right under the *Pico*; and since bound to the *West-Indies* in the Year 1656, in the *Society* of *Topsam*, a *Ship* I had Command of, was put by *Westerly Winds* to the *Eastward*, that we had sight of the *Pico* of *Tenariff*, it bore off us *South*; about Noon I was resolved to make Observations of the height thereof, to try Conclusions with my *Quadrant* of 20 *Inches Semidiameter*, described in Chap. 16 of the second Book; and by the Rules of *Quadrature* I made these Observations following. On the 5th. of *May* 1656 I observed, and found the *Sun*'s apparent *Meridian-Altitude* 81 *degr.* 44 *min.* his *Declination* 19 *degr.* 08 *m.* the *Latitude* 27 *degr.* 20 *min.* the *Latitude* of *Pico* I found formerly to be 28 *degr.* 20 *min.* difference of *Latitude* 60 *min.* or *miles*, which in the following *Figure* I make one half of my *Horizontal Base* AD; then at the same time observing the *Height* or *Altitude* of *Pico*, I found it 24 *degr.* 14. *min.* Therefore according to the *Sphericality* of this *Terrestial Globe* consisting of the *Earth* and *Sea*, I demonstrated the following *Figure*. The Section of the *Arch* AEFS represents the *superficies* of the *Horizon* of *Tenariff*; or a part of an *Arch* of a great *Circle*, the *Meridian* AD, the difference of *Latitude* 60 *mile*, DC *Pico* the *perpendicular*, EB a second Observation, *N* the *North* part of the *Horizon*, *S* the *South* part, C the *Port* of *Garrachica*. See Fig. 98 in the following Schemes.

Now to find the *perpendicular* Height thereof, you have the Rules at large set down in the 16th. Chap. of the *Description* and *Use* of the *Quadrate* and *Quadrant*; and by the first Rule of the *Quadrant* I found the *perpendicular* Height D *Pico* 27 *min.* or *mile*, if the *Sea* were a flat plain as a *Table-board*, as the *Right-Line* ABDS represents.

But having 3 days of Fair Weather, in sight of *Pico* I made a second Observation, and ran to it with my *Ship* until I made an *Angle* with the *Pico* of 45 *degr.* 00 *min.* as *Pico* EC: or *Pico* BD; and had the apparent *Meridian-Altitude* of the *Sun* 81 *degr.* 29 *min.* the *Declination* 19 *degr.* 22 *min.* *Latitude* the *Ship* is in 27 *degr.* 53 *min.* difference of *Latitude* 27 *min.* or *miles*, being equal to the Height, as BD to the *perpendicular* DC *Pico*, the *Angle* of 45 *degr.* being the most sure as can be made by any *Instrument* which confirms the first, and the Height of the *Pico* of *Tenariff* to be 27 *min.* or *miles* High, if the *Sea* were flat as a Board.

But touching the *Hypothesis*, that the *Earth* and *Sea* makes a Round Body, It is generally agreed upon by all the *Philosophers*, *Astronomers*, *Geographers*, and *Navigators* Antient and Modern; and therefore the distance of a *degree* 60 *min.* reckoned in the Heavens by Observations of the *Sun* or *Stars* is more than 60 *miles* upon the *superficies* of the *Earth* and *Sea*,, as appears by several Experiments made by able *Artists*: but especially by the Labour and Industry of our own Countrey-Man Mr. *Richard Norwood*, as you may see in his second Chap. of his Book the *Sea-mans Practice*, made by him betwixt *York* and *London*. He makes it evident that 1 *degree* of a *Great Circle* on

on the Earth, is near 367200 *Feet*, which in our *Statute-Poles* of 16 and ½ *Feet* to the *Pole* is 22254 *Poles*, and about half, and theſe reduced into *Furlongs* at 40 *Poles* to a *Furlong*, makes 554 *Furlongs* and 14 *Perch*; and laſtly, theſe reduced into *Engliſh-miles* of 8 *Furlongs* to a *mile*, makes 69 *miles* and 4 *Furlongs* 14 *Poles*, that is 69 and ½ *miles* and 14 *Poles* to 1 *degree* upon the *ſuperficies* of the Earth and Sea. And ſeeing a *Degree* is the 360 part of any *Circle*, equally *divided* in the *Circumference*; Therefore if we can find how many *Feet*, *Perches*, *Furlongs*, or *Pieces*, are in a *Degree* of known *meaſure*: then can we preſently reſolve how many of the ſame known *meaſure* are in the *Circumference* of any *Circle* ſo *divided* on the Earth and Sea; for if there is 367200 *Feet* in one *degree* of a *Great Circle* upon the *ſuperficies* of the Earth and Sea, therefore it is evident, that if you *multiply* 367200 by 360 *degr.* the *Product* is 132192000 *Feet*, which reduced into *Poles*, is 8011636, and theſe reduced into *Furlongs*, are 200290 *Furlongs*, and 36 *Poles*; And laſtly, theſe reduced into *miles*, are 25036 *Engliſh miles*, 36 *perch* for the *Circumference* of the Earth and Sea.

How to know the *Circumference* of the *Earth*.

And now if you deſire the *Diameter* and *Semidiameter* of the *Earth*, as it is proved by *Archimedes*, That the proportion of the *Circumference* of a *Circle* is to the *Diameter* thereof almoſt as 22 to 7; therefore by the *Rule* of *Proportion*, *Multiply* the *Circumference* of the *Earth*; namely, 132192000 by 7, and *divide* the *Product* 925344000 by 22, the *Quotient* is 42061091, which is the *Diameter* of the *Earth* in *Feet*: and the half thereof, namely, 21030545 is the *Semidiameter* of the ſame, or *diſtance* of the *ſuperficies* of the *Earth* and *Water*, to the *Center*, being 21 *millions* of *feet*, and a little more; and theſe reduced into *miles*, as we did the *Circumference*, ſhews the *Diameter* of the *Earth* to be 7966 *miles*, and ſomewhat more: and the *diſtance* to the *Center* or *Semidiameter* 3983 *miles*; and thus is found the *Circumference*, *Diameter*, and *Semidiameter* of the *Earth* and *Sea*, and alſo the *quantity* of a *degree* of the ſame *meaſure* in *Engliſh meaſures* of *Feet*, *Perch*, *Roods*, and *miles*. Therefore if you do ſtill retain a *degr.* in the *Heavens* to be 60 *minutes*, you may find how many *Feet* is in a *mile* on the *Earth* and *Water*, if you *divide* 367200 *feet* by 60, the *Quotient* will be 6120 *feet*; which doubled, and *divided* by 33, and *half-feet* to a *perch*, the *Quotient* is 370 *perch*, and 30 *foot remains*: *divide* 370 by 40 *perch* to a *furlong*, and the *Quotient* is 9 *Roods* or *furlongs*, and 10 *perch* or *poles remains*, divided by 8 *Roods* to a *mile*, the *Quotient* is 1, and 1 *remains*; ſo that a *minute* in the *Heavens* by this *Rule* and *meaſure* upon the *ſuperficies* of the *Earth* and *Water*, contains 1 *mile*, 1 *rood*, 10 *perch*, and 30 *foot*; therefore my *degr.* 60 *min.* of *Latitude* at my firſt Obſervation, is found by theſe *Rules* to be 69 and ½ *miles*, 14 *perch* my *diſtance* upon the *Arch* of a *Great Circle* from the *Latitude* of *Pico*: therefore working by the Rules given of *Quadrature* in the 16th. Chapter of the 2 Book, the true Height of *Pico* will be found to be 31 $\frac{25}{121}$ *miles*, and the *diſtance* from the Eye to the Top of the *Pico* A, P, will be found by the Rules in the 16th. Chap. 76 $\frac{22}{100}$ *miles*.

How to find the *Diameter* & *diſtance* to the *Center* of the *Earth* and *Sea*.

6120
2
2240

22
33(3)f.
xzz40(370
3333
33

(1
37(0(9
4(0
R.
(1
9(1R.
8

The true *height* and *diſtance* from the Eye.

And working the ſecond Obſervation by the ſame Rules, your *difference* of *Latitude* 27 *minutes* B D will be found to be 31 *miles*, 2 *furlongs*, 14 *perch*, 18 *foot*, which is 31 ½ *miles* and a little more; which is almoſt the ſame Height found by the firſt Obſervation: and the *diſtance* from the Eye to the Top of the *Pico* is 44 $\frac{84}{100}$ *miles*.

By theſe ſeveral Rules you may find the Height of any *Mountainous Iſland* at *Sea*, or *High-Land* on the *Main-Land*, if you can come bring it *North* or *South* of you, and make any Obſervation of the *Sun* or *Stars*; or if you will but truſt to a *Log-Line* marked after the former Experiment, that a *mile* doth contain 6120 *feet*, or 1020 *fathoms*; and ſo 3 *miles* or a *League* contains 18360 *feet*, or 3060 *fathoms*: then if you intend to keep a *Log* by ½ *minute-Glaſs*: and becauſe half a *minute* is $\frac{1}{120}$ part of an *hour*, *divide* 6120 by 120, the *Quotient* is 51 *feet*. Therefore ſo many 51 *feet* or *knots* ſhe runs out in ½ a *minute*, ſo many *miles* ſhe *ſails* an *hour*. By this Rule you may keep your Reckoning exactly; for I had Experience in *ſailing North* and *South* by a *Log-Line* marked after the rate of 6000 in a *mile*, that is by the ſame Rule 50 *feet* or 8 *fathoms*, and 2 *feet* to every *knot*, that I have *run* or *ſailed* almoſt 22 *Leagues* to raiſe or depreſs the *Pole* 1 *degr.* on a *Great Circle*; and if any have impartially taken the

ſame

ſame notice and care, (or will) they ſhall find the like. But many that follow the old Rule 300000 *feet* to a *degree*, and 5000 *feet* to one *mile*, and 60 *mile* to a *degree*, or the 120 part of an *hour* 41 $\frac{2}{3}$ *Feet*, or 7 *fathoms* to the *knots* upon the *Log*: when they *Sail North* or *South*, and find the *Log* to fall too ſhort of their Obſervation, imputes it to ill *Steerage*, Sometimes to the Variation of the *Compaſs*, or ſome Errour in their *Plotts*, or ſome *Current*, or other accident, but will not believe the truth a great many without they had Angels ſhould tell them ſo, a great many have ſo much Ignorance and Obſtinacy. But for confutation of ſome of the Antient Authors, eſpecially *Cleomedes*, whom I take to be a Man which did never ſee, nor obſerved *Tenariff Pico*, He affirms, that there is no Hill found to be above 15 *furlings* in Height; and of Mr. *Hughes*, He ſaith, that if *Mercury* himſelf ſhould affirm a Hill to be above 4 *miles* in Height, he will not believe him; neither will I believe them that are of that Opinion, be they what they will, without they could prove the foregoing Obſervation not good, and produce better of their own made by the *Pico* of *Tenariff*; and ſo much for the *Altitude* of *Hills* at *Sea*.

Chap. VI.

How to find the Diſtance *of a* Fort, *or* Walls *of a* City, *or* Caſtle, *that you dare not approach for fear of* Gun-Shot; *Or the* Breadth *of a* River *or* Water, *that you cannot paſs, or* Meaſure *over it, made by* 2 Stations, *with the* Quantity *of the* Angle *at each* Station.

SUppoſe from ſome private place as at A, you eſpy a *Caſtle*, *Fort*, *Tree*, or place whatſoever, that you dare not approach for fear of *Gun-Shot*, *Marſh-Grounds*, or a *River* betwixt you, or ſome other Impediments, that you cannot make your ſecond *Station* in any open place, but are forc'd to make it in ſome other ſecure Place at B; therefore plant your *Inſtrument* or *Compaſs* at A, and direct the *Sights* to C and B, take the *Quantity* of the *Angle* CAB 46 *degr.* 00 *min.* and go to B, and take the *Quantity* of the *Angle* ABC 79 *degr.* 0 *min.* then *meaſure* the *diſtance* of the 2 *Stations* A and B 350 *fathoms*.

Then by a *Plain Scale*, or by the *Line* of *Sines* on the *Scale* of *Scales*, you may preſently reſolve the *diſtance*, as I do by the *Tables*. See Figure 99 in the following Schemes.

As the *Sine* of 55 *degr.* 00	ACB	991336	46 *d.* 00 *m.*
to 350 *Fathoms*,	AB	354406	79 00
So is the *Sine* of 79 *degr.*	ABC	999194	125 00
to the *diſtance*		1353600	180 0
AC 419 : $\frac{40}{100}$		362264	125 0
			55 0

As the *Sine* of 55 *degr.* 00	ACB	991336
is to AB 350 *Fathoms.*		354406
So is the *Sine* of 46 *degr.* 0	CAB	985693
to BC 307 $\frac{40}{100}$ *Fathoms*, the *diſtance* required.		1340099 348763

Sect. I.

How to take the Breadth *of a* River.

Suppose you were to take the *Breadth* of a *River*, as I have at *Crocken-Pill*, which runs betwixt *Glocester-shire* and *Somerset-shire*, and found the *breadth* of the *Water* upon a Spring-Tide 40 *Perch* or a *Furlong*; you must do it thus. Being on the *River-side* as in the former *Figure* at E, there set your *Compass*; Observe some *mark* on the other side of the *Water*, as at D; then set a *mark* at E, and go *square-wise* either to the *right-hand*, or to the *left* from these 2 *marks*, so far, until you spie the *mark* D on the other side the *Water* doth justly make an *Angle* of 45 *degr.* with the *mark* E; and this will be when you come to F; then *measure* carefully F E, the *distance* of the 2 *Stations*, and that shall be equal to the *breadth* of the *River*: so that if FE be 10:20: 30: 40: 50: or 100 *Poles*, or *Yards*, or *Feet*, the *breadth* is the same. The like may be done by any other *Angle*, as if you go to G, and make an *Angle* of 26 *degr.* 30 *min.* in D; then is the *distance* G E twice the *breadth*; but ever if you can get an *Angle* of 45 *degr.* for that is the best and readiest *Angle* to find out such a *distance*; therefore if you can, use no other.

And the like way of Working you may do at *Sea*, if you gain the *Sight* of any *Cape*, *Head-Land*, or *Island*, set it by your *Compass* when you see it, without altering your *Course*, make an *Angle* of 45 *degr.* And by your *Plain-Scale* if you have kept a good account of your Way by the same Rules as before, you shall have the true *distance* of your *Ship* from the first Place, or *Cape*, or *Head-Land*, or *Island* whatsoever: Or you may get the *Slope-side* D F or D G if you *measure* it with your *Compasses*, and apply it to the same *Scale* of equal *parts* by which you put down the *distance* E F or E G. Thus you may find the *distance* from the *Ship*, to any *Cape*; These are made so plain by the Rules before-going, that it need no further precept.

Sect. II.

Being upon the Top of a Hill, Tower, Steeple, *or a* Ships Top-Mast-Head, *there observing the* Angle *of* distance *from you, To find the true* distance *thereof.*

You may do this by your *Quadrant*; thus. Let the *height* of the *Hill*, *Tower*, *Steeple*, or *Ships Top-Mast-Head* be 40 *yards*, or any other *measure*: and from it you see an *House*, *Tree*, or *Place* whatsoever, and you desire the *distance* from you. You have been shewed already to find the *height* of a *Tree*, *Tower*, *Hill*, or *Steeple*; by this Rule we will shew you how to stand upon them, and take the *distance* from any thing else, *viz.*

Let the *height* of the *Tower*, or *Mast*, or *Hill* be 40 *yards*, and let the *Angle* of *distance* taken with your *Quadrant* be 80 *degrees*, being 10 *degrees* under the *Line* of *Level*; this is the Rule for all such Questions.

As the *Tangent Compl.* 80 *degr.* which is 10 *d.*	924631
is to the *height* 40 *Yards.*	260206
So is the *Radius*	10
to the *distance* from the Top of the *Tower* or *Hill* 226 $\frac{9}{10}$	235575 *yards.*

SECT. III.

By the way of your Ship, *and any* 2 Angles *of* Poſition; *to find the* Diſtance *of any* Iſland, Cape, *or* Head-Land *from you.*

YOu have been ſhewed how to do it with a *right-Angle* of 45 *degr.* already; but with a little more trouble, you ſhall learn to do it by any 2 *Angles* whatſoever.

As for Example.

Suppoſe you were Sailing full *South* from A towards B, and from A ſhould eſpy *Land* at C bearing 2 *Points* from you to the *Weſtward*, as *S S W.* or *S W* 22 *deg.* 30 *min.* and Sailing ſtill upon your *Courſe* until you come to B, you obſerve the Place bears from you juſt 4 *Points*, or *S W* 45 *degr.* which is the double of the *Angle* obſerved at A. If in this manner you double any *Angle*; that is, let your firſt *Angle* be what it will, you muſt Sail until you have doubled that *Number*; then you may aſſure your ſelf that the *diſtance* you have Sailed between A and B, is juſtly equal to the *diſtance* between B and C, B being the ſecond Place where you made your laſt Obſervation, and C being the Place obſerved. So that if A B be 12 *miles*, B C is likewiſe 12 *miles*; and this you may do without further trouble or Calculation, and may lay it down by your *Plain-Scale*, as I have done this following *Figure.*

In all ſuch Queſtions remember that the *Angles* at the ſecond place of Obſervation, ſhall be either juſt the double, if you go nearer to the Place, or elſe juſt the half if you go further off than the *Angle* at the firſt place. Therefore the firſt *Angle* you may take at Random, no matter what it is, ſo you be careful to obſerve when you be juſt upon the double, or the half, ſo that by Calculation you may reſolve it almoſt with as little trouble as a *Right-Angle*, which is made plain thus. In the *Triangle* A B C the *acute Angle* being the outward at B, being 45 *degr.* the *obtuſe* or *inward-Angle* being the *Complement* thereof to 180 *degr.* muſt be 135 *degr.* and the *Angle* at A being 22 *degrees* 30 *min.* being added to this, makes 157 *degr.* 30 *min.* which *Subſtracted* from 180 *degr.* there muſt needs reſt for the *Angle* at C 22 *degr.* 30 *min.* Now this *Angle* at C being equal to the *Angle* at A 22 *degr.* ½; therefore the *ſide* A B oppoſite to the one *Angle*, muſt needs be equal to the *ſide* B C oppoſite to the other *Angle*, as you ſee by this Caſe.

See Figure 100 in the following Schemes.

180	0
45	0
135	0
22	30
157	30
180	00
d. 22	30

And by theſe Rules you may find all the oppoſite *ſides.*

As the *Sine* of the *Angle* A C B 22 *degr.* 30 *min.* —— 958283
to the *diſtance* Sailed 12 *mile* A B —— 107918
So is the *Sine* of the *Angle* C A B 22 *degr.* 30 *min.* —— 958283
to the *diſtance* B C 12 *miles.* —— 1066201

To find the *diſtance* A C { As the *Sine* of A C B 22 *deg.* 30 *min.* 958183 } 107918
is to A B 12 *miles.* —— 107918 }
So is the *Co-ſine* of 135 *d.* which is 45 *d.* 984948
to the *diſtance* from the firſt Place —— 1092866
of Obſervation A C 22 *miles.* 17/31 *parts.* 134583

Chap. VII.

How to take the Diſtance *of divers* places *one from the other, remote from you, according their true Situation in* Plano, *and to* rotract *(as it were) a* Mapp *thereof by the* Compaſs *and* Pplain-Scale.

THe *Problem* ſerveth chiefly to deſcribe upon Paper or Parchment all the moſt Eminent and Remarkable places in a *Country, Town,* or *City*, whereby a *Mapp* thereof may be exactly made by help of a *Table* of Obſervations following, as with a little Practice you may ſoon perceive.

Upon ſome high Piece of *Ground* make choice of 2 *Stations* as A and P, from whence you may plainly diſcern all the Principal Places which you intend to deſcribe in your *Mapp*; then at A Plant or ſet your *Compaſs* fixed, and turn the *Index* about to P; and let A and P bear one of the other *North* and *South*, as you ſee marked with the Letters N and *S*: and then direct your *Sights* to the ſeveral Marks from A to B, C D E F G H I K L M obſerving what *degr.* the *Index* cutteth. As ſuppoſe your *Inſtrument* fixed at A, and the *Sights* directed to B, the *Index* cutteth *N E* 83 *degr.* 50 *min.* and likewiſe the *Index* directed to C, cuts 82 *degr.* 5 *min.* and ſo in like manner take the reſt of the *Angles*, as you ſee them in the *Table* following, which were noted down by you in a Paper-Book when they were taken.

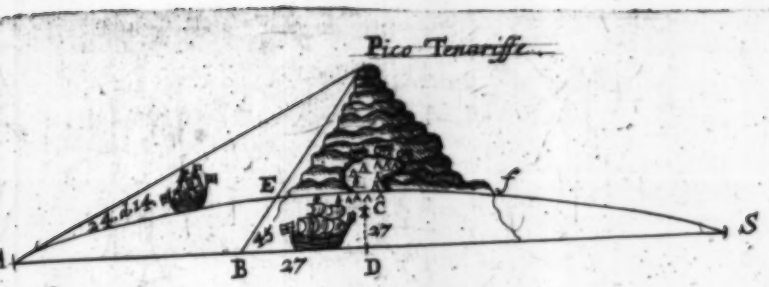
The *Stationary Diſtance* 730 *Perch*, or 2 *miles* 90 *Perch.*

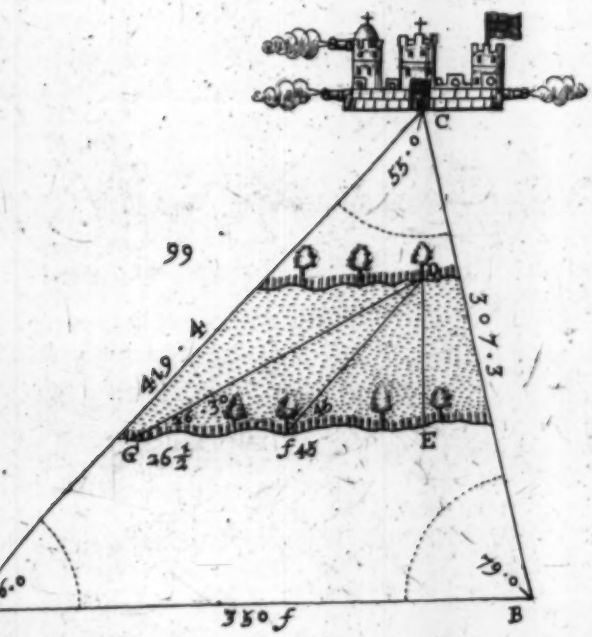
Places	*Angles*	*deg.*	*min.*
A B	N E	83	50
A C	S E	82	05
A D	S E	64	50
A E	S E	56	20
A F	S E	45	26
A G	S E	41	30
A H	S E	24	40
A I	S E	09	00
A K	S W	11	00
A L	S W	16	00
A M	S W	23	00

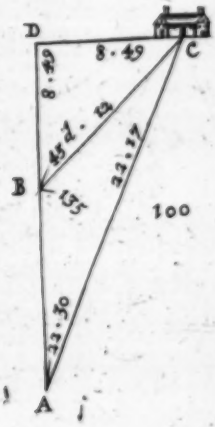
Next *meaſure* the *Stationary diſtance* A P, which was found 730 *Perch*, which you muſt Note down likewiſe in your *Book*; then plant your *Compaſs*, and fix him at P, that the *Chard* may ſtand *North* and *South* on the *Stationary-Line* P A, then turn the *Index* to your firſt Mark K, the *Index* cuts *N W* 24 *degrees*; Likewiſe turn the *ſights* to L, and *mark* the Inclination to the *Meridian*, and put it down *N W* 17 *degr.* and ſo do by all the reſt of the former *Marks* or *Points*; and Note them down as you ſee in this *Table* P K: P L: P M: P I: P D: P B: P C: P E: P G: P F: P H: and where the *Lines* Interſect each other, drawn from the two Places A and P, there muſt you deſcribe the ſeveral Places, to which you made Obſervation, where you may Write the Name of the Places.

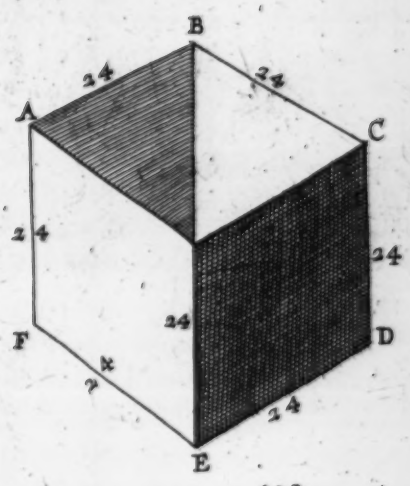
See Figure 110

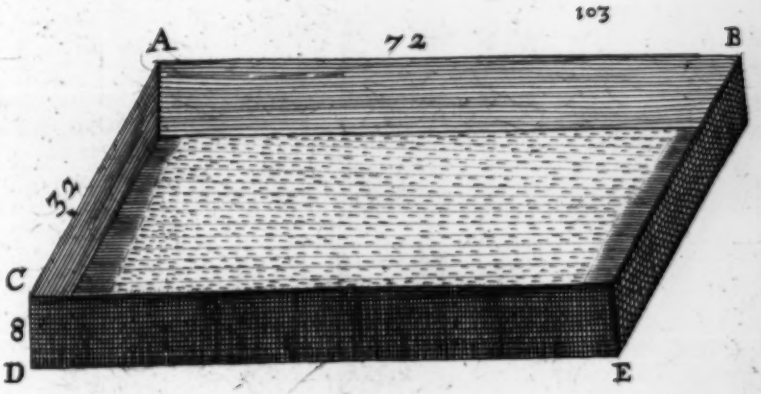
Laſtly,

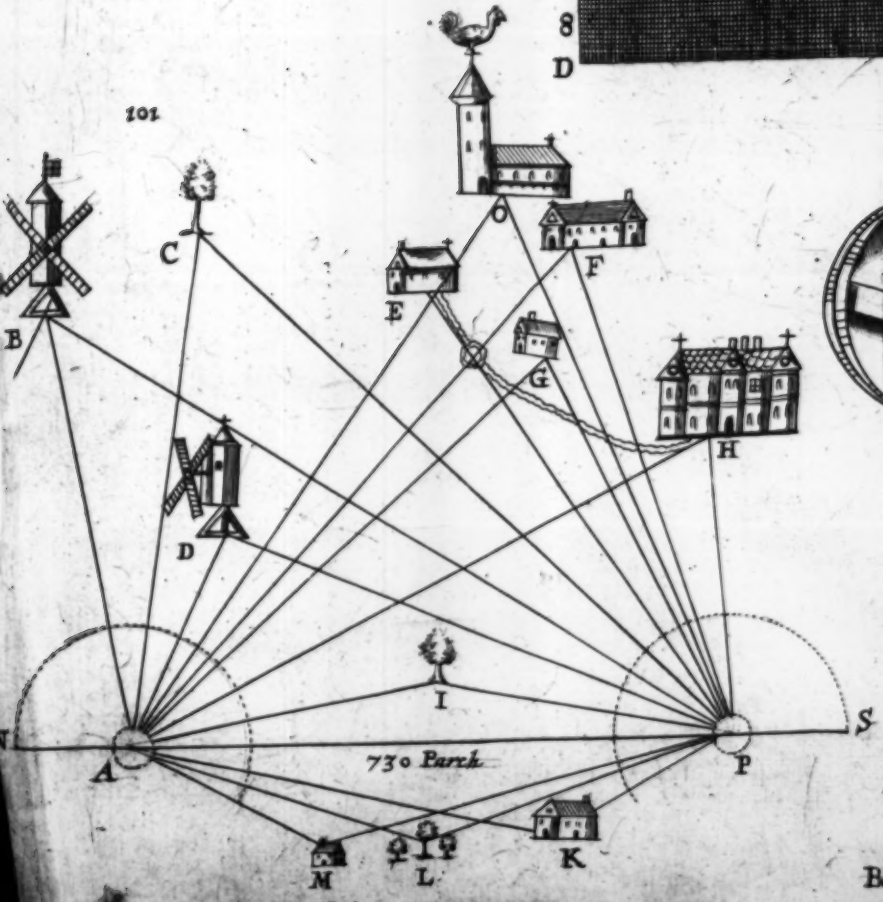

Pico Tenariffe.
E
C
f
S
B
27
D
45
98

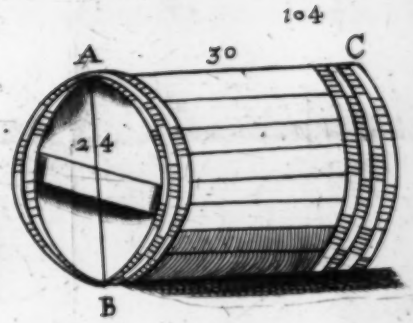

C
55.0
99
449.4
307.3
G 26½
f 45
E
350 f
B


D
8.49
C
8.49
45d. 8
33.17
B
155
100
33.30
A


B
24
24
A
C
24
24
24
F
D
E
102


103
A
72
B
32
C
8
D
E


101
C
O
F
E
G
B
H
D
I
S
730 Parch.
A
P
M
L
K


104
A
30
C
24
B


105
A
24
B

Places	*Angles*	*Deg.*	*Min.*
PK	*NW*	24 :	00
PL	*NW*	17 :	00
PM	*NW*	12 :	00
PI	*NE*	9 :	00
PD	*NE*	21 :	00
PB	*NE*	33 :	50
PC	*NE*	43 :	40
PE	*NE*	54 :	10
PG	*NE*	64 :	00
PF	*NE*	73 :	20
PH	*NE*	87 :	15

See Figure 101

Laſtly, If you would know the *Diſtance* of any of the Places thus deſcribed, one from another, you have no more to do, but open your *Compaſſes* to the two Places on the Paper; and then apply it to the ſame *Scale*, by which you laid down the *ſtationary Diſtance* AP, which in this *Figure* was laid down by a *Scale* of 20 *Perch* to an *Inch*: the like is to be underſtood of *Fathoms*, *Yards*, or *Feet*; and ſo applyed, it will without farther trouble effect your deſire.

And you may *Protract* it by help of your *Line* of *Chords*, and *Line* of *equal parts*, as this you ſee is done; or by the help of your *Protractor*, as before directed: and if there is any other Notable *Caſtle*, or *Tower*, or *Place*, lying in a *right-Line* with your Obſervation upon any *Hill*, you muſt remember always in taking of *Inacceſſible Heights* and *Diſtances*; as alſo in *Plotting Unpaſſable Diſtances*, by reaſon of *Water*, that you take theſe two *ſtationary diſtances* as far aſunder as may be. And if at any time you require the *Altitude* of a *Church*, *Caſtle*, or *Tree*, ſtanding upon a *Hill*, you muſt perform it at two Operations; firſt by taking the *Altitude* of the *Church*, or *Caſtle*, or *Tree* together as one *Altitude*; and ſecondly by taking the *Altitude* of the *Hill* alone; then by *ſubſtracting* the *height* of the *Hill* from the whole *height*, the *remainder* ſhall be the *height* of the *Caſtle*, or the like.

And here Note alſo, That in the taking of all manner of *Altitudes*, whether *acceſſible* or *inacceſſible*, you muſt always add the *height* of your *Inſtrument* from the *Ground* to the *height* found, the total is the true *height*. And thus much briefly touching this Matter.

The ART of Gaging of Veſſels.

CHAP. VIII.

The Uſe of the Line *of* Numbers, *and the* Lines *on the* Gaging Rod *or* Staff, *and the Rules in* Arithmetick *in* Gaging *of all ſorts of* Veſſels, (viz.) *to* Gage *a* Cube-Veſſel, *to* Meaſure *any* Square-Veſſel, *and a* Cylinder-Veſſel; *Alſo*, Barrels, Pipes, *or* Hogſheads; *to* Meaſure *a* Veſſel *part out*, *to* Meaſure *a* Brewers-Tun, *or a* Maſh-Fat, *to* Meaſure *a* Cone-Veſſel, *to* Meaſure *a* Riſing *or* Convex Crown; *and alſo a* Convex *or* Falling Crown *in a* Brewers-Copper; *alſo a* Brewers Oval Tun.

PROBL. I.

The true Content *of a* Solid Meaſure *being known*, *To find the* Gage-Point *of the ſame* Meaſure.

THe *Gage-Point* of a *Solid Meaſure* is the *Diameter* of a *Circle* whoſe *ſuperficial Content* is equal to the *ſolid Content* of the ſame *meaſure*; ſo the *ſolid Content* of a *Wine-Gallon* according to *Wincheſter meaſure*, being found to be 231 *Cube-Inches*: if you conceive a *Circle* to contain ſo many *Inches*, you ſhall find the *Diameter* thereof to be 17: 15 by this Rule. *Example.* A *Wine-Veſſel* at *London* is ſaid being the 66 *Inches* in *length*, and 38 *Inches* in the *Diameter*, would contain 324 *Gallons*. If ſo, by the *Line* of *Numbers* we may *divide* the ſpace between 324 and 66 into two *equal parts*, the *middle* will fall about 146, and that *diſtance* will reach from the *Diameter* 38 unto 17: 15 the *Gage-point* for a *Gallon* of *Wine* or *Oyl* after *London meaſure*: the like reaſon holdeth for the like *meaſure* in all places. Thus likewiſe you may diſcover the *Gage point* for *Ale-meaſure*, an *Ale-Gallon*, as hath been of late diſcovered containing 282 *Cubique-Inches*; for as 1 is to 1: 273, ſo is 282 to 356, 3 whoſe *ſquare-root* is 18: 95 the *Gage-point* for *Ale-meaſure*, becauſe of Waſt and Soil exceeding that of *Wine* above two *Inches*: or you may find it as before by the *Content* 256, 3 and the *length* 66, and the *Diameter* 38, as before. There are ſeveral other Rules to find it, but theſe may ſatisfy to ſave *Prolixity*, Mr. *Phillips*, and others, have found and proved by *Example*. That there is 288 ¼ *Cubique Inches* in an *Ale-Gallon*, which I believe is the Truth: But that which is received by Authority, are theſe ſorts of *meaſures*, the *Wine-meaſure* is 231 *Cubique Inches*, and for *Ale* 282 *Cubique-Inches* or *Beer*; and for Drie things, as *Corn* 272 *Inches*. Theſe Rules are undeceivable with Authority.

Therefore

Therefore take notice you muſt be very careful in all your *meaſures* of all ſorts of *Veſſels*, their *length*, *breadth*, and *depth*, as alſo of the *Head* and *Bong*; for all ſmall Errours in them may increaſe too much in the *Content*: for the miſtake of a quarter of an *Inch* in a large *Veſſel*, may make you miſreckon a *Gallon* in the *Content*; therefore how to be careful is beſt known to the Practicioner more than I can declare by many words.

PROBL. II.

The Deſcription of the Gaging-Rod, *or* Staff.

THe moſt uſeful *Gaging-Rod* is 48 *Inches* or 50 in *length*, upon one *ſquare* there is 2 *Lines*, a *Line* of *Numbers*, and a *Line* of 48 *Inches*, every *Inch divided* into 10 *parts* for the ready *meaſuring* of any *Veſſels*, *length*, *breadth*, or *depth*.

But for the *meaſuring* of *Great-Veſſels*, there is two *Staffs divided* into *Inches* and 10 *parts*, made to ſlide.

On the ſecond *ſide* is two *Lines*, the firſt to *Gage* by the *Head*, and the ſecond by the *Bong*, which *added* together *multiplyed* in the *length*, will give the *Contents*; As by *Example* in the following *Problem*, and Uſe of a *Table* of *Wine meaſure*.

And the third *ſquare* is two *Diagonal Lines*, for the *Gage* of *Wine* the firſt; and for *Ale*, the ſecond: which ſhews the *Contents* to the $\frac{1}{2}$ *part* of a *Gallon* according to 282 *Cubique-Inches* in a *Beer* or *Ale-Gallon*, the Uſe in *Probl.* 7.

On the fourth *ſide* is a *Line* of *Segments*, or 63 *Gallons divided* into 1000 *parts*, as you may have the Uſe by the following *Table* in *Probl.* 8. The making of this *Staff* is beſt known to the *Inſtrument-Maker*, by reaſon it muſt be exactly done; and you may have them of Mr. *Philip Standridge* in *Briſtol*, and by Mr. *Hays*, and *John Brown* in *London*, *Mathematical Inſtrument-Makers*.

PROBL. III.

The Deſcription of Symbols *of words for Brevity in* Arithmetick.

WHere theſe following *Characters*, are placed, you are to Work by theſe Rules, and that will reſolve your Queſtion.

+	*Plus* or *Addition*, which is as much as to ſay *add*.
—	*Minus* or *Subſtraction*, then you muſt *ſubſtract*.
×	*In* or *Multiplication*, now you are to *multiply*.
$\frac{1}{2}$	To *Divide* by 2 or any other *Number* under the *line*.
=	*Equal* to the thing deſired.
q	*Square* the *Number* given.
2—*q*	*Twice ſquared*, when 2 ſtands before the *Letters*.
C	*Cube* the *Numbers*.
Z	*Sum* and Z *q* *Square* of the *Sum*.
√ *q*	To *Extract* the *ſquare Root*.
Z,	The *Sums* of the *Squares*.
X	*Difference*, and X. *difference* of the *ſquares*.
X *q*	*Squares* of the *difference*.
Æ	The *Rectangular* or *Plain* of them, which is the *Product* of 2 *Numbers multiplyed*.

PROBL. IV.

Prob. IV.

How to Meaſure *a* Cubical Veſſel.

Suppoſe we have a *Cubical Veſſel* to *meaſure*, whoſe *ſides* let be A B C D E F, which let be every way 24 *Inches*, and I deſire to know how many *Gallons* of *Wine* or *Ale* the ſame will hold.

See Figure 102 in the following Scheme.

☞

For Beer *or* Ale *by the* Line *of* Numbers.

Extend the *Compaſſes* always from the *Gage-Point* (which for *Ale* is 16 $\frac{3}{10}$) unto the *ſide* of the *Cube* 24 *Inches*, the ſame extent will reach from the ſame 24, turning twice over unto 49 *Gallons*, and better.

For *Wine*.

Extend the *Compaſſes* always from the *Gage-Point*, which for *Wine* is 15 $\frac{3}{10}$ unto the *ſide* of the *Cube* 24 *Inches*: the ſame extent will reach from the ſame 24, turning twice over unto 59 $\frac{81}{100}$ *Gallons*, which is almoſt 60 *Gallons* of *Wine*.

The Arithmetical *way*.

$\frac{AB, C}{282}$ = *Gall.* of *Ale* 49. $\frac{AB, C}{231}$ = *Gallons* of *Wine* 59 $\frac{81}{100}$.

Prob. V.

How to Meaſure *any* Square Veſſel.

Suppoſe we have a *Square Veſſel* to *Meaſure*, whoſe *ſide* A B let be 72 *Inches*, and *breadth* A C 32, and the *depth* C D 8 *Inches*.

See Figure 103

☞

By the Line *of* Numbers *for* Ale.

You muſt firſt find a *mean proportion* between the *length* A B 72, and the *breadth* A C 32, by *multiplying* it together, and taking the *Square Root* thereof, or taking the middle way between 72, and 32 on the *Line* of *Numbers*, and you will find it 48 for the *mean*.

Now Extending the *Compaſſes* from the *Gage-point* 16 $\frac{3}{10}$ to the *mean Number* 48 *Inches*, the ſame extent will reach from the *depth* C D 8 *Inches*, turning twice over unto 65 $\frac{16}{100}$ *Gallons*.

For Wine.

To find how many *Wine-Gallons* it is, Work by the *Gage-point* 15 $\frac{3}{10}$ as you did in the laſt Rule, and you will find near 79 $\frac{3}{10}$ *Gallons*; or you may find a *mean proportion* between the *breadth* A C 32, and the *depth* C D 8: which will be 16 *Inches*, and ſo Work according to the former Rule.

How to Work the ſame without the Gage-Point.

Example for all. Extend the *Compaſſes* from the *Ale-Gallon* 282 unto the *length* A B 72: the ſame *diſtance* will reach from the *breadth* A C 32 unto 8: $\frac{17}{100}$ *Gallons*: for an Inch *depth*, ſo for 8 *Inches* you may preſently find it to be 65 $\frac{16}{100}$ *Gallons*.

For Wine-Gallons.

Take the *Numbers* 231 the *Gage-point*, which by the former work you ſhall find 9 $\frac{971}{1000}$ *Gallons* for 1 *Inch depth*.

The Mathematical *way*.

$$\frac{ABX: ACX\ CD}{282} = \textit{Ale-Gallons}\ 8\ \tfrac{17}{100}$$

$$\frac{ABX\ AC\ XCD}{231} = \textit{Wine-Gallons}\ 9\ \tfrac{971}{1000}$$

The *Brewers Coolers* are *meaſured* all one as this *Veſſel* is.

Prob. VI.

PROB. VI.

How to Meaſure *a* Cylinder Veſſel.

Suppoſe the *Diameter* of the *Head* A B be 24 *Inches*, and the *length* thereof A C be 30 *Inches*, To find the *contents* in *Ale-Gallons*. Extend the *Compaſſes* always from the *Gage-point*, which for *Ale* is 18 $\frac{21}{168}$ *Inches* unto the *diameter* 24 *Inches*; the ſame *diſtance* will reach from the *length* 30 *Inches* turned twice over unto 48 $\frac{11}{196}$ *Gallons*. See Figure 104

For Wine.

Extend the *Compaſſes* from the *Gage-point* 17 $\frac{11}{168}$ unto the *diameter* 24; the ſame *diſtance* will reach from 30 turned twice to 58 $\frac{7}{14}$ *Gallons*.

The Arithmetical *way*.

For Ale. $\frac{AB^2 \times AC}{359}$ ═══ *Ale-Gallons* (viz.) 48 $\frac{11}{196}$

For Wine. $\frac{AB^2 \times AC}{294}$ ═══ *Wine-Gallons*, (viz.) 58 $\frac{7}{14}$

PROB. VII.

How to Meaſure *a* Globe-Veſſel.

Suppoſe the *diameter* or *height* of the *Globe* be A B 24 *Inches*: Then to know the *Contents* in *Ale* or *Wine*, it is thus. See Figure 105

For Ale.

Extend the *Compaſſes* from the *Gage-point*, which is 23 $\frac{21}{168}$ unto the *diameter* A B 24 *Inches*; the ſame *diſtance* will reach from the ſame 24 turned twice over unto 25 $\frac{5}{7}$ *Gallons* of *Ale*.

For Wine.

Extend the *Compaſſes* from the *Gage-point* 21 unto the *diameter* 24 turned twice over, as before, you ſhall have 31 $\frac{1}{7}$ *Gallons*.

The Arithmetical *way*.

For Ale $\frac{.AB.C}{540}$ ═══ *Gallons*, (viz.) 25 $\frac{60}{154}$

For Wine. $\frac{AB.C}{440}$ ═══ *Gallons*, (viz.) 31 $\frac{40}{154}$

PROB. VIII.

How to Meaſure *a* Barrel, Pipe, Butt, Punching, Hogſhead, *or ſmall* Cask.

Suppoſe you have a *Cask* to *meaſure*, whoſe *length* is A B 27 *Inches*, and *depth* at the *Bung* C D 23 *Inches*, and *breadth* at the *Head* E F 20 *Inches*.

You are to find a *mean-diameter* between the *Head* and the *Bung* by theſe Rules.

Take the *difference* between 23 and 20, which is 3: which being *multiplyed* always by 7, the *Product* here is 21, and *divided* by 10, the *Quotient* will be 2 $\frac{1}{10}$ which *added* to the leſſer *diameter* 20, you have 22 $\frac{1}{10}$ for the *mean-diameter*.

Another way to find the *mean diameter* is thus. A *Veſſel* having 20 *Inches diameter* at the *Head*, 23 *Inches* at the *Bung*, I would know the *mean-diameter*: 20 and 23 makes 43, the half is 21: 50 the leſſer taken out of the greater, the *difference* is 3, which *reduced* into 10 is 300; then *divide* by 45, the *Product* is $\frac{6}{10}$ *added* to 21 $\frac{5}{10}$ makes 22 $\frac{1}{10}$ *Inches* the *mean-diameter* required. Then

23
20
3
7
21
2(1(2 $\frac{1}{10}$
2 0
23—0
20—0
43—0
21—50
3
100
3
300
3
6
300(6
45
21—5
0 6
22—$\frac{1}{10}$

Then for Ale.

Extend the *Compaſſes* from the *Gage-point* always 18 $\frac{21}{100}$ unto the *Mean-diameter* 22 $\frac{1}{10}$, the ſame will reach from the *length* 27 *Inches* turned twice over, to 36 $\frac{7}{10}$ *Gallons*.

For Wine.

Extend the *Compaſſes* always from the *Gage-point* 15 $\frac{21}{100}$ unto 22 $\frac{8}{10}$, the ſame will reach from 27 to 44 and $\frac{8}{10}$ *Gallons*, as before.

The Arithmetical *way.*

M ſtands for *Mean*, D for *Diameter*, MD for *mean-Diameter*.

For *Ale*. $\frac{CD\,2\,q\,+\,:\,EF\,q\,XAB}{1077}$ = 2 *Gallons* (viz.) 36 $\frac{77}{100}$.

For *Wine*. $\frac{CD\,2\,q\,+\,:\,EF\,q\,XAB}{880}$ = *Gallons* 44 $\frac{71}{100}$.

See Figure 106 & There is another way to Work this *Veſſel* or *Queſtion*, by the *Mean-diameter* which was before found to be 22 $\frac{1}{10}$ *Inches*; and that is after the *Cylinder-Veſſel*, which may be reſolved by the *Line* of *Numbers*, as before, and by *Arithmetick*, thus.

These ſort of *Caſk Gaged* 5 ſeveral ways.

For *Ale*. $\frac{MD\,q\,X\,A\,B}{359}$ = *Gallons*, (viz.) 36 $\frac{79}{100}$.

For *Wine*. $\frac{MD\,q\,XAB}{294}$ = *Gallons*, (viz.) 44 $\frac{81}{100}$ *ſen-*.

By the Diagonal Line *on the* Rod *or* Staff.

To know what it ſhall hold in all.

Take the *meaſure* with your *Rod* from the *Bong hole* at C to the lower part of the *Head* at F, as the *Line* F C, which in the *Example* is near 25 $\frac{5}{10}$ *Inches*: ſo if you would know how much *Ale* the *Caſk* will hold, you ſhall find the *Bong Hole* to cut in the *Diagonal Line* 36 $\frac{7}{10}$ *Gall.* And for *Wine* it will cut 44 $\frac{1}{4}$ *Gall*, the *Contents* required.

Extend the *Compaſſes* from 231 to 282, the ſame extent will reach from the *Contents* in *Wine-Gallons* 44 $\frac{8}{10}$ to 36 $\frac{7}{10}$ the *Contents* in all *Gallons*.

By the ſame Rule you may know what an *Ale-Caſk* will hold in *Wine*.

A Table for the *Gaging* of *Veſſels*.

The *Diameter* in *Inches*. D	Head. Gpts.	Bong. Gpts.		Head. Gpts.	Bong. Gpts.
01	0,001	0.002	31	1,089	2,178
02	0,004	0.009	32	1,160	2.321
03	0,010	0.020	33	1,234	2.468
04	0,018	0.036	34	1,310	2.620
05	0,028	0.056	35	1,388	2.776
06	0,041	0.081	36	1,469	2.938
07	0,056	0.111	37	1,551	3.102
08	0,072	0.145	38	1,636	3.272
09	0,092	0.183	39	1,724	3.448
10	0,113	0.226	40	1,813	3.625
11	0,137	0.274	41	1,904	3.809
12	0,163	0.326	42	2,000	4.000
13	0,192	0.383	43	2,096	4.191
14	0,222	0.444	44	2,194	4.388
15	0,255	0.510	45	2,296	4.588
16	0,290	0.580	46	2,398	4.796
17	0,328	0.557	47	2,504	5.007
18	0,367	0.734	48	2,611	5.222
19	0,409	0.818	49	2,721	5.442
20	0,453	0.906	50	2,833	5.665
21	0,500	1.000	51	2,948	5.895
22	0,548	1.097	52	3,065	6.129
23	0,600	1.199	53	3,184	6,367
24	0,653	1.305	54	3,305	6.609
25	0,708	1.416	55	3,428	6.856
26	0,766	1.532	56	3,554	7.108
27	0,826	1.692	57	3,682	7.364
28	0,888	1.777	58	3,813	7.625
29	0,953	1.906	59	3,945	7.890
30	1.020	2.040	60	4,080	8.160

The Uſe of the two Lines *upon the* Rod *marked* Head *and* Bong; *and of this* Table *for* Wine-meaſure.

The Uſe of this *Table* is the *Root* of the uſual Making and Uſe of the *Lines* on the *Rod* or *Staff* only. In the *Table* you have the perfect *Number*, but you muſt *number* upon the *Staff*, for 10 account 100, and every ſmall *Diviſion* is 10; and you muſt eſtimate the *parts* of theſe *ſmall Diviſions*: then is the Work all one as with this *Table*, (viz.)

You muſt *meaſure* the *Diameter* firſt at the *Head*, and find the *Number* in the *Table*, or *Staff* belonging to it; then *meaſure* the *Diameter* at the *Bong*, and likewiſe in the *Table*, or on the *Staff*, find the *Number* belonging to that; then *add* thoſe two together, and *multiply* the *Sum* thereof by the *Inches* of the *Veſſels length*, *meaſured* from *Head* to *Head* in the *Inſide*.

The

The *Table* and *Staff* shews for 20 *Inches* at the *Head.* —— 0,453
For 20 *Inches* at the *Bong.* —— 1,199
These 2 *added* together, make —— 1652
27
Which being *Multiplyed* by —— 11564
27, the *length*, —— 3304
Makes —— 44604

According to this Operation, it should be 44 *Gallons* $\frac{604}{1000}$ *parts*, which *difference* is of no Moment in these Conclusions.

The Table *of* Segments.

Gals	Parts.	Gal.	Parts.	Gal.	Parts.
63	10000	42	6188	21	3712
½	9705		6223	½	3647
62	9530	41	6158	20	3582
½	9390		6094	½	3517
61	9280	40	6040	19	3452
½	9170		5976	½	3387
60	9065	39	5913	18	3321
½	8962		5850	½	3255
59	8862	38	5787	17	3189
½	8765		5724	½	3123
58	8661	37	5662	16	3056
½	8580		5600	½	2986
57	8491	36	5535	15	2918
½	8404		5476	½	2847
56	8319	35	5415	14	2775
½	8236		5354	½	2703
55	8154	34	5294	13	2630
½	8072		5234	½	2556
54	7990	33	5174	12	2481
½	7909		5115	½	2405
53	7829	32	5057	11	2328
½	7758		5000	½	2250
52	7672	31	4943	10	2171
½	7595		4885	½	2091
51	7519	30	4826	9	2010
½	7444		4766	50	1928
50	7370	29	4706	8	1846
½	7297		4646	50	1764
49	7225	28	4585	7	1681
½	7153		4542	50	1509
48	7082	27	4462	6	1420
½	7012		4400	50	1329
47	6944	26	4338	5	1235
½	6877		4276	50	1138
46	6811	25	4213	4	1038
½	6679		4150	50	1935
45	6679	24	4087	3	1035
½	6613		4024	50	830
44	6548	23	3960	2	720
½	6483		3906	50	602
43	6418	22	3842	1	470
½	6353		3777	50	295

PROBL. VIII.

By the Line *of* Segments *on the* Rod *or* Staff, *and also by a* Table, *How to find the* Quantity *of* Liquor *in a* Cask *that is part full.*

SUppose you would know the *Quantity* of *Liquor* in a *Cask* whose *depth* at the *Bong* is 23 *Inches*, as before, and let the *Liquor* be in *height* 16 *Inches*, and the whole *Cask* to hold 44 $\frac{71}{100}$ *Gallons*. See Figure 107

By the *Line* of *Numbers* on the *Staff*, the proportion will be, as the whole *depth* 23 *Inches* is to the *depth* in *Liquor* 16 *Inches*, so is 1000 to 592 *parts*.

Which being sought for in the *Segment-line* on the *Staff*, you shall have in the *Line* by it 46 $\frac{11}{100}$ *Gallons*.

Now if you extend the *Compasses* from 63 to 46 $\frac{71}{100}$ *Gallons*; the same *distance* will reach once from 44 $\frac{71}{100}$, the *Contents* of the whole *Cask* to 33 $\frac{6}{10}$, that is, 33 $\frac{6}{10}$ *Gal.* of *Wine* in the *Cask*. 33—$\frac{6}{10}$

Then by this Rule always as 63 *Gallons* is to 46 $\frac{71}{100}$ *Gallons*, so is 44 $\frac{71}{100}$ *Gallons* to 33 $\frac{60}{100}$ *Gallons* of *Wine* in the *Cask*. This *table* is made to ½ or $\frac{50}{100}$ *parts* of a *Gallon*: by same Rules you may make him *Quarts* or *Pints*.

By the same Rule Work for *Beer* or *Ale*.

To Work this *Arithmetically* is somewhat tedious; wherefore I have here Calculated a *Table* whereby you may perform it very easy by help of the *Rule* of *Three*.

Example.

In the last *Vessel* whose *depth* at the *Bong* is 23 *Inches*, and *depth* in *Liquor* 16 Inches

The first *Rule* of *Proportion*.

As 23 is to 16, so is 10000 to 6921 *parts*, which sought for in the nearest *Number* in the *table* of *Segments* you shall have against it 46 $\frac{71}{100}$ *Gallons* nearest.

The *top* or *Bong* is uppermost in the Column to the *left hand* 63 *Gal.* the *bottom* is ½ to the *right hand Colum.*

Then again.

23 - 7 : 10000 to 3049 — As the whole *Radius* 63 *Gallons* is to 46 $\frac{71}{100}$, ſo is the *Gage* of your *Veſſel* 44 $\frac{81}{100}$ *Gallons* to 33 $\frac{14}{100}$ *Gallons* near, as before.

3043 anſwers 15 : $\frac{76}{100}$ — After this manner of Working you ſhall have for 7 *Inches depth* of *Liquor* 11 $\frac{19}{100}$ *gallons.*

63 : 15. 76 ſo 44 $\frac{81}{100}$ = 11 $\frac{33}{100}$ *Gall.* — And ſo by theſe Rules you may work for any other *Cask.*

Prob l. IX.

How to Meaſure *a* Brewers Tun, *or a* Maſh-Fat.

Let the *Tun* be ACDE, whoſe *Diameter* in the *bottom* let be ED 98 *Inches*, and the *Diameter* at the *top* AC let be 90 *Inches*, *add* both the *Diameters* together, you have 188 *Inches*; then take the half thereof, and it is 94 *Inches*, this is the *Mean-diameter* FG; then get the *height* of the *Tun*, which let be AB 40 *Inches*. Now to know how many *Barrels* of *Ale* or *Beer* it will hold according to 36 *Gallons* to the *Barrel*, you ſhall Work thus.

By the Line *of* Numbers.

Extend the *Compaſſes* always from 113 $\frac{7}{10}$, which is the *Gage-point* for a *Barrel* unto the *Mean-diameter* 94, the ſame *diſtance* will reach from the *height* 40 *Inches* turned twice over unto 27 $\frac{1}{2}$ of a *Barrel.*

The Arithmetical *way by the* Mean-diameter.

$$\frac{FGq \times AB}{359} = \text{Gallons } 984\ \tfrac{5}{10}.$$

Which being *divided* by 36, you have 27 *Barrels* 12 $\frac{1}{2}$ *Gallons.*

Or thus for *Barrels.*

$$\frac{FGq \times AB}{12924} = \text{Barrels } 27\ \tfrac{12}{100},$$ near as before.

This *Arithmetical* way by the *Mean-diameter* is not abſolute true, yet near enough for *Brewers Tuns*, by reaſon there is *difference* of *Diameters* between the *bottom* and the *top*; yet it is ſeldom above 7 or 8 *Inches*: But to have an Exact way which alſo ſerveth for *Coopers* or any, take this way for Working this *Tun* for an *Example.*

The trueſt *Arithmetical* way.

$$\frac{EDq + ACq, + EDX.\ ACZ, \times AB}{1077} = 985\ \textit{Gall.}\ \tfrac{111}{1077}$$

Divide 985 $\frac{5}{10}$ *Gallons* by 36 *Gallons* in a *Barrel*, and the *Quotient* 27 *Barrels*, and 13 *Gallons* remains: ſo the one will hold 27 *Barrels* 13 *Gallons* $\frac{111}{1000}$ *parts.*

Or thus for *Barrels.*

$$\frac{EDq + ACq, + EDXAC.\ ZXAB}{38772} = 27\ \textit{Barrels}\ \tfrac{121}{1000}.$$

Prob l. X.

PROBL. X.

How to Meaſure *a* Cone-Veſſel, *ſuch as is a* Spire *of a* Steeple, *or the like, by having the* Height *and the* Diameter *at the* Baſe.

SUppoſe the *Diameter* at the *Baſe* AB be 98 *Inches*, and the *height* DC 490 *Inches*.

Then by the *Line* of *Numbers* for *Barrels* of *Ale* or *Beer*.

Extend the *Compaſſes* from the *Gage-point* 169 $\frac{8}{10}$ unto the *Diameter* AB 98, the ſame will reach from the *height* of the *Cone* DC 490, turned twice over unto 121 $\frac{4}{10}$ *Barrels* ferè. See Figure 109

This is the beſt Proportion to Work for great *Cones* to have it in *Barrels*, but ſmall *Cones* have it in *Gallons*.

Then thus Work.

Extend the *Compaſſes* from the *Gage-point* 32 $\frac{8}{10}$ unto the *Diameter* of the *Baſe* 98, the ſame will reach from the *height* of the *Cone* 490 twice turned unto 4369 $\frac{147}{1000}$ *Gall.*

The *Arithmetical* way.
For Gallons.

$$\frac{ABq \times DC}{1077} = 4369\ \tfrac{147}{1000}\ \textit{Gallons}.$$

Which being *divided* by 36, you have 121 $\frac{14}{100}$ *Barrels*.

Or thus for *Barrels*.

$$\frac{ABq, \times DC}{38772} = 121\ \tfrac{147}{1000}\ \textit{Barrels}.$$

An Example.

The *Brewers Tun* before *meaſured* may be *meaſured*, after this manner by *Cones*, by this *Example* in this *Figure* I have proportioned the ſame *Tun* in this *Cone*, as you may prove thus by, the *Rule* of *Proportion* to find the *Diameter* on the *top* EF 90, it was before.

Work thus.

As CD 490 is to AB 98, ſo is CG 450 to EF 90 *Inches*; and ſo back again, to find the *height* of the greater *Cone*, ſay, as the *difference* of the *Diameters* 8 *Inches* is to the *height* of the *Tun* 40 *Inches*: ſo is the *Diameter* of the *bottom* AB 98 *Inches* to the greater *height* DC 490 *Inches*, from whence *ſubſtract* 40, there *remains* the *height* of the leſſer *Cone* GC 450 *Inches*.

Now Working as before, for the *Contents* of each *Cone*.

The greater *Cone* will be found to be —— 4369 *Gall.* —— 547 *Parts.*
And the leſſer *Cone* to contain —— 3384 *Gall.* —— 432 *Parts.*
Which *ſubſtracted* from the greater *Cone*, there *remains* 985 *Gallons* $\frac{115}{1000}$ *Parts*, } 985 *Gallons* $\frac{115}{1000}$

For the *Brewers Tun*, as before found in the 9 PROBL. which is 27 *Barrels* 13 *Gallons* $\frac{1}{10}$.

Prob. XI.

How to Measure *a* Segment *or* portion *of a* Globe *or* Sphere, *which serves for a* Convex Signet *or* Rising, *or* Falling Crown *in a* Brewers Copper.

ADmit you have the *Diameter* of the *Crown* A B 80 *Inches*, and the *height* thereof C D 6 *Inches*.

A Convex Rising Crown.

See Figure 110 The *Falling Crown* is nothing but this *Figure*, the upper part turned down.

☞ Note that a *Crown* is seldom less then 2 *Inches*, nor above 12 *Inches*; for in *Briſtol* in all their *Crowns* belonging to the *Brewers Coppers*, the leaſt that was found, was 1 $\frac{6}{10}$ *Inch*, and the greateſt *height* or *depth* 11 $\frac{2}{10}$ *Inches*.

By the Line *of* Numbers.

Extend the *Compaſſes* from the *Gage-point* 18 $\frac{2}{10}$ unto the *Diameter* A B 80, the ſame *diſtance* will reach from half the *height* C D 6, which is 3 being turned twice unto 53 *Gallons* $\frac{1}{2}$ ferè.

The *Arithmetical* way for *Ale* or *Beer-Gallons*.

$$\frac{AB^{q}.\ X\ \frac{1}{3}\ CD}{359} = 53\ \tfrac{43}{100}\ \textit{Gallons}.$$

Prob. XII.

How to Reduce Ale-meaſure *into* Wine; *And likewiſe to* Reduce Wine-Gallons *into* Ale.

For Example.

THere is a *Veſſel* that holds 60 *Gallons* of *Ale*; the Queſtion is how many *Gallons* of *Wine* it will hold.

The Proportion of the *backward Rule* of 3.

As 282 *Ale* is to 231 *Wine* :: ſo 60 *Ale* to } 73; $\frac{12}{47}$ *Wine-Gallons*.
Or thus. As 94 is to 77 :: ſo is 60 *Ale* to }

The reaſon is thus, 231 *Ale-Gallons* is 282 *Wine-Gallons*, or 77 *Ale-Gallons* is 94 *Wine-Gallons*.

Or, as 282 to 231, ſo is 116. 4 to 95. 30, and as 231 : 282, ſo is 95 : 30 to 116 $\frac{4}{100}$, or extend the *Compaſſes* from the *Ale-gallon* 282 to the *Wine-gallon* 231, the ſame *diſtance* will reach from 60 to 73 $\frac{3}{4}$ *Gallons*, or from 77 to 94, or from 94 to 77.

Prob. XIII.

How to Meaſure *a* Brewers Oval Tun.

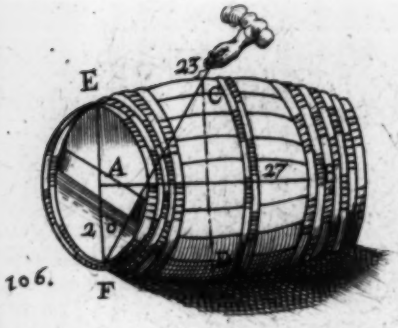
LEt the *length* in the *bottom* be A B 120 *Inches*, and the *breadth* E F 90; let the *length* at the *top* be C D 112 *Inches*, and the *breadth* 84; alſo the *depth* 40 *Inches* C A.

See Figure 111 *A Brewers* Oval Tun.

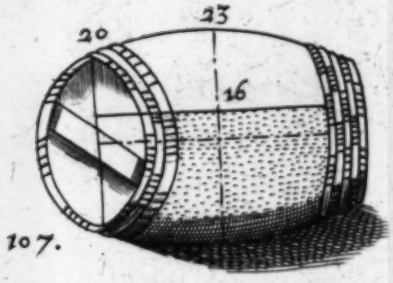
☞ Now to Work this, you muſt find a *Mean-proportion* between the *length* in the *bottom* 120, and the *breadth* 90 *Inches*.

The *Arithmetical* way.

A B × E F $\sqrt{q}$ = 103 — 92. That is, *Multiply* the two *Numbers* together, and of the *Product* thereof *extract* the *Square Root*; ſo ſhall you have the *Mean-proportional Number*.

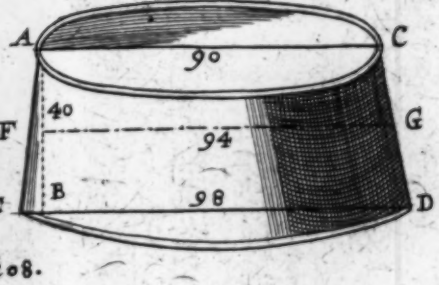


106.

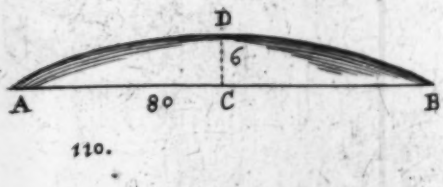


107.

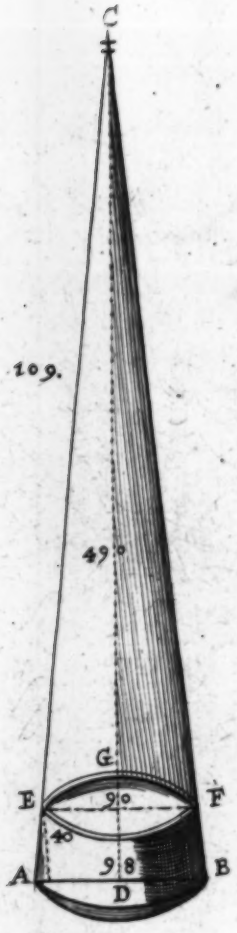
The Tun.



108.

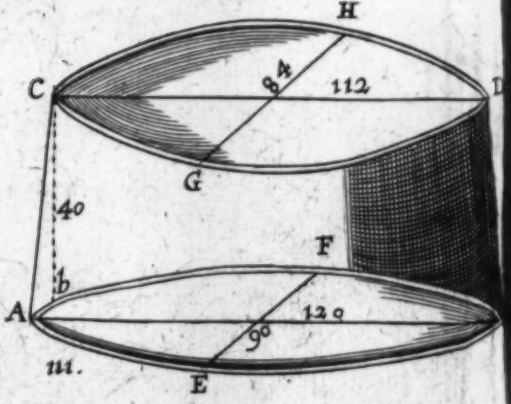


110.



109.

A Brewers Ovall Tun.



111.

Book V. p. 34. 35.

By this Rule you will find a *Mean-proportion* between the 120 at the *bottom*, and the *breadth* 90, to be 103 and 92.

And likewise for the *top* between 112 and 84, will be 97; then as before, you shall find the *Sum* to be 200 — 92; the *half* thereof is the *Mean-diameter* 100; $\frac{16}{100}$ *Inches*; so shall you Work all one, as you did in the *Round Tun*.

How to get the Mean-diameter *by the* Line *of* Numbers.

Let the *Numbers* given be 120, and 90. Extend the *Compasses* from 90 to 120: *Divide* that in half, the same *distance* will reach from 90 to 103 $\frac{92}{100}$ almost 104 the *Mean Number* required; and so likewise between the *Number* 112 and 84, you will find it 97; then as before, you shall find the *Sum* 200: 92 and $\frac{1}{2}$ 100 $\frac{46}{100}$ *Inches*.

The *Arithmetical* way, as before, is thus.

$$\frac{M.\ Diam: \text{X C A}}{12924} = 31\ \tfrac{1}{16}\ \textit{Barrels of Ale or Beer.}$$

And in *Gall. M. Diam.* X A C = 1119 $\frac{219}{1000}$ *Gallons of Beer or Ale.*

By the Line *of* Numbers *for* Barrels.

Extend the *Compasses* always from the *Gage-Point* 113 $\frac{7}{10}$ to the *Mean-diameter* 100 $\frac{46}{100}$: the same will reach from the *height* 40 turned twice over, to the Quantity of *Barrels* of *Ale* or *Beer* 31 $\frac{3}{10}$.

PROBL. XIV.

How to Gage *a* Vessel *by* Oughtred's Gage-Rule.

THis is an *Instrument* by taking the *length* in *Inches* and 10 *parts*, and is as Exact as any way *Instrumental* extant; both the *Diameters* at the *Head* and *Bong*, with a *Line* called *Oughtred's Gage-Line*.

The Use is thus.

Take the *Diameter* at the *Bong* with those *Divisions* before said from that end where the *Divisions* begin to be *numbred*, and set that down twice: and on the *Diameter* of the *inside* the *Head* in this manner,* and then *add* them together, as here you see the *length* in *Inches*. Suppose to be (30. 82) then say, as 1, is to 1: 77, so is 30: 82 to 54 $\frac{55}{100}$ of a *Gallon*, being a little more then $\frac{1}{2}$ a *Gallon*, or 54 *Gallons* $\frac{1}{2}$ the *Content* of a *High Country Hogshead*; and so you may do by any other great or small sort of *Cask*.

* 0 | 63
0 | 63
0 | 51
1 | 77

The end of the 8 Chapter *of* Gaging Vessels.

Chap. IX.

Wherein is ſhewed both Arithmetically *and* Inſtrumentally *How to* Meaſure *exactly all kind of* plain Superficies, *as* Walls, Timber-work, Roofs *of* Houſes, Tyling, Board, Glaſs, Wainſcot, Pavement, *and the like*; *as alſo* Timber *and* Stone.

Prob. I.

FOraſmuch as it is very requiſite for a Compleat Artiſt to know how to *Meaſure* all manner of *Buildings*, as *Walls*, *Timber-work*, *Tyling*, and ſuch like; I ſhall in the following *Example* make Illuſtration thereof.

Note this, that *Walls* and *Tyling* are *meaſured* by the *Rod* of 18 *Feet*, *Wainſcot* by the *Yard* or *Feet*, and *Board* and *Glaſs* by the *Foot* only. Therefore *meaſuring* any of theſe things, conſideration muſt be had to the juſt Form and *Figure* thereof: Then by the following Rules you will ſoon have the *Area Content* thereof.

As for Example.

Suppoſe there be a *Wall* in the Form of the *Figure*, and it is required to know how many *Perch*, or *Rods*, *Yards*, and *Feet* are contained therein.

The *Arithmetical* way for *Perch*.

$$\frac{ABXAD, \text{ or thus, } ABXAD.ZX2}{16\frac{1}{2}} = 76 \text{ Perch.}$$

Extend the *Compaſſes* always from $16\frac{1}{2}$ to the *length* 66, the ſame Extent will reach from the *height* 19 *Foot* unto the true *Contents* of the *Wall* 76 *Perch*.



Then to bring it into *Rods*, and *Feet*, and *Yards*, Work as before. *Multiply* 66 by 19, the *Product* is 1254 *Feet*; which *Divide* by 324 (becauſe there is ſo many *Square Feet* in a *Rod*,) and the *Quotient* is 3 *Rods*, and 282 *remains*, which *divide* by 9 (for ſo many *Feet* is contained in a *Yard*,) and the *Quotient* is 31 *Yards*, and 3 *remains* which is *Feet*; ſo this *Wall* being 66 *Foot long*, 19 *Foot high*, there *contains* 3 *Rods* $\frac{1}{4}$ *Yard*, 4 *Feet* (for as 81 *Feet* or 9 *Yards* is a quarter of a *Rod*.

But

But ſuppoſe A B C be a *Govel Dormant Pike*, ſuch you muſt *meaſure* them as *Triangles*, to bring it into *Feet*. *Multiply* 16 the *Perpendicular* by half the *Baſe* A C, the *Product* is 160, the *Contents* in *Feet* double it: *divide* by 33 *half* Feet, the *Quotient* is 9 *Perch*, 11 $\frac{1}{3}$ *Feet remains*. Work by the *Line* of *Numbers* as in the laſt Rule, and it will be 9 *Perch* $\frac{97}{100}$, (or *divide* 160 by the *Quotient* 17 *Yards* and 7 *Feet*, *remains* the true *Contents* of the *Dormant Pike*, that is 1 *Rod*, 8 *Yards*, 7 *Feet*.



But in *Meaſuring* of *Chimneys* which require more Workmanſhip then other ordinary *Walls*, they are uſually accounted at *double meaſure*. Firſt *meaſure* them as *ſingle-meaſure*. Take the *length* of the *braſt Wall* E F, and the 2 *ſide Angles* D E, and F C, which *Multiplyed* into the *height* C B the *Product* of that *Multiplication* doubled, yieldeth the *Content*.

According to the *Cuſtomary meaſure* allowed for *Chimneys* that ſtand in a *Govel* or *Side-wall*, (but if the *Chimney* ſtand by himſelf, the *Back* is to be *meaſured* with the reſt of the *Chimney*; but the *Back* ſtanding againſt a *Govel* or *Wall* is accounted part of the *Wall*, and muſt not be *meaſured* with the *Chimney*.



Admit this *Figure* L I K. G H. A B. D C be a *Chimney* to be *meaſured*, and according to *double meaſure*, the *Content* is required.

Firſt *meaſure* the *Baſe* C F the *Braſt-wall* D C, and F C the *ſide Angles*, which together makes 24 *Feet*; next take the *height* of the *Square* C B 18 $\frac{15}{100}$ *Feet*, which *Multiplyed* together, the *Product* is 435: 60 *Feet* for the *Content* of the *Figure* A B D C. Then for the □ and *Braſt-Wall* G H, and *ſide Angles* is 15 *Feet*, *height* n H 6: 26 *Feet*: X as before, makes 93: 90 *Feet*, for the *Content* of the *Square* G H *m*: *n*.

In like manner of Working, you will have the *Contents* of the *Square* I K: R V: 92: 16, likewiſe the *Chimney-Shaft* in *compaſs* is 9 *Feet*, and 8 *Foot high*. × together as before, is 72 *Feet* for the *Contents*: *add* theſe 4 *Sums* together, the *Sum* is 693: 66 *Feet* doubled is 1387 *Feet* $\frac{32}{100}$ *Feet* the *Content* of the *Chimney* according to *Cuſtomary meaſure*.

	Feet.	Parts.
The *Squares*. A B D C:	435:	60
G H *m n*:	93:	90
I K R V:	92:	16
The *Shaft* I L:	72:	00
The *Sum*	693:	66
doubled.	693:	66
The Total *Sum*.	1387:	32

Which *reduced* into *Perches* as before, is 5 *Perch* 26 *Foot* $\frac{97}{100}$ *Parts*; or into *Rods*, is 4 *Rods* 10 *Yards* 1 *Foot* $\frac{32}{100}$ according to theſe *Meaſures*: But it is fit the *Maſter-Workman* ſhould *Meaſure* it, and ſhould have ſo much *Arithmetick*, as to *Multiply* and *Divide*, or elſe he cannot be a Compleat *Workman* in every part.

Note that after the ſame order *Slate-work* and *Tyling* are *meaſured* either by *Perch* or *Rods* of 18 *Foot ſquare*. Note that *Roofs* of *Houſes*, and *Timber-work*, *Partition-Floors*, and the like, are reckoned by the *Square* of 10 *Foot*, but Worked by the ſame *Rule*, as have been already delivered in this *Problem*; therefore it needs no other precept.

PROBL. II.

Probl. II.

How to Measure Boards, Glass, Pavement, Wainscot, *and the like.*

IN the last *Problem* we have shewed that *Boards*, *Glass*, *Pavement* and *Wainscot*, and the like, they are commonly accounted by the *Foot* or *Yards*; Therefore to make this plain, we shall instance only upon *Boards* which are cut out in *long squares* commonly.

How to Measure *them.*

Take the *length* and *breadth* in *Inches* and *Parts*, *Multiply* one by the other, the *Product* will shew the *Content* in *Inches*; (that *divide* by 144 the *Numbers* of *Inches* in one *Foot*, the *Quotient* will tell you the *Number* of *Feet*, and the *remainder* is *Inches.*

For Example.

Such *Rules* are made by *Walter Hays* in *More-Fields*, and in *Briefly* by *P. Staynard.*

Admit I have a *Board* that is 7 *Foot* long, and 18 *Inches* broad; *Multiply* 84 *Inch.* which is in 7 *Feet* by 18 *Inches*, the *Product* is 1512; which *divide* by 144 the *Number* of *Inches* in a *Foot* of *flat-measure*, and the *Quotient* shews 10 *feet*, and 72 *remains*, which is $\frac{1}{2}$ 144; therefore the *Board* contains 10 *foot* $\frac{1}{2}$; but many times the *Board* falls out to be *broader* at one end, then it is at the other, *add* together the *breadth* at each end; then take the $\frac{1}{2}$ for the true *breadth.*

And Work as before; But commonly *Artificers* have a Useful *Line* put upon their *Rules* for their ready *Measuring* of *Board* and *Timber-measure*; but this is the Exactest way, though that is near; and what have been said of *Board-measure*, only the same is to be understood is the way of *Measuring* not only *Boards* and *Glass*; but likewise all manner of *Wainscot*, *Pavement*, *Floors*, and such like; they depend upon one and the same *Geometrical* Ground, though they be reckoned by different *measures*, as you see by the *Perch*, *Rod*, *Square*, *Yard* or *foot* according to the Custom of the Place, therefore needs no further *Example.*

Extend the *Compasses* always from 12 *Inches* unto the *breadth* 18 *Inches*, the same extent will reach from the *length* 7 *foot*, unto the *Number* of *Square foot* in the *Board*, which is 10 $\frac{6}{10}$ *foot.*

$$\frac{\text{AB } 18 \textit{ Inch} \times \text{AD } 7 \textit{ foot}}{12} = 10\ \tfrac{6}{10}\ \textit{feet.}$$

Probl. III.

The Mensurations *of* Solid Bodies *of* Timber *and* Stone, *and first of* Squared-Timber.

WHatsoever hath *length*, *breadth* and *thickness*, is called a *Solid-body*; as *Timber*, and *Stone*, and the like, which are usually *measured* by the *foot*: and therefore you are to observe that a *foot* of *Timber* or *Stone* is accounted a *foot square* every way in the Form of a *Die*; whereby it plainly appears that a *foot* of *Timber* is 12 times more than a *foot* of *Board*, which it 144 *Inches*; but a *foot* of *Timber* must be 1728 *Inches.*

To find the *Square-Root* by the *Tables.*

For *Timber* that is *squared* you may find the *Contents* thereof on this wise; First find a *Mean* betwixt the two *Sides* at the *End.* Admit the *height* at the *End* be AC 16 *Inches*, the *breadth* thereof AB 25 *Inches* } By the *Tables* — 120412
the *half Sum.* } *Add* together — 139794

Sum. 260206
The half *Sum.* 130103 is the *Square.*

Root and *Mean-proportion* between 16 and 25 which is 20.

By

By the *Line* of *Numbers*.

Divide, and take the *middle* between 16 and 25, and you will find the *Mean* 20 as before; Then to know how many *foot* of *Timber* is in a *Square* of 16 *Inches* in *height*, 25 *Inches broad*, and 14 *foot long*.

Extend the *Compaſſes* always from 12 *Inches* unto the *Mean-proportion* or *ſide* of the *Square* 20 *Inches*; the ſame will reach from the *length* 14 *foot* turned twice over to $38\frac{2}{12}$ *foot* of *Timber*.

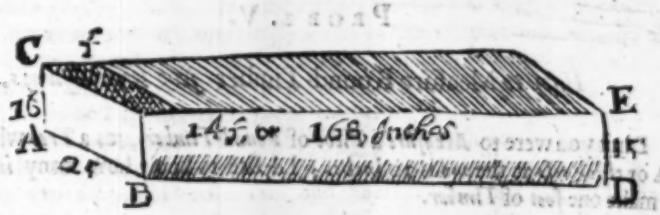
The *Arithmetical* way.

Thus. $\frac{AB \times AC. \times AD}{144}$ = to the *Contents* in *feet*. $38\frac{112}{144}$

Or thus. $\frac{AB \times ACAD}{1728}$ = *reduced* into *inches* 168 in 14 *foot*

$38\frac{1536}{1728}$ *feet*, as before found.

Yet it is common with the *Carpenters* to *add* the *broad* and *narrow ſide* together, and to take the *half* thereof; the true *Square* that way is very erroneous, eſpecially when the *difference* between the *ſide* is much. A common Error amongſt moſt *Carpenters*.



In the former *Example* one *ſide* is 25, the other 16, the *Sum* 41, the half $20\frac{1}{2}$ *inches*; that is, half an *inch* too much, as was proved by the former Rules; that is juſt 20 for the *Mean* or true *Square*: ſo that by taking $\frac{1}{3}$ the 2 *ſides* $20\frac{2}{3}$, it makes the *piece* of *Timber* 40 *foot* $\frac{4}{12}$, when indeed it is but $38\frac{2}{12}$ *feet*, which is 1 *foot* and *half* too much.

Now if a *Piece* of *Timber* that is *tapering*, the Common Rule is to take the *Mean* betwixt both *ends*; and ſo to Work as in the laſt Form, but it is not abſolute true.

For *Example*.

Admit a *Piece* of *Timber* were *Square* at one *end* 25 *inch*. and at the other 15 *inches*, and 14 *foot* long.

This is the abſolute *Arithmetical* way.

$\frac{ZAB, DE + Æ. XAD}{432}$ = *Contents* $39:\frac{7}{12}$

PROBL. IV.

How to find how many Inches *in* length *will make one* Foot *of* Timber, *being alike in the* Squares.

SUppoſe you have a *Piece* of *Timber* that is *four-ſquare* 16 *inches* every way, and you would know how many *inches* in *length* will make one *foot* of *Timber*.

By the *Line* of *Numbers*.

Extend the *Compaſſes* always from 12 *inches* to the *ſide* of the *Square*, which in this Queſtion is 16 *inches*, the ſame turned twice over from 12 *inches*, will reach to $6\frac{3}{4}$ *inch*. in *length* for one *foot* of *Timber*.

The Arithmetical *way.*

$\frac{1728}{AC\,16\,q} = \frac{192}{C} = 6\frac{75}{256}$ or $6\frac{75}{100}$ *Inches* as before.

Having the *side* of a *Square piece* of *Timber*, at the *end* and the *length* in *feet*, to find how many *feet* is contained therein.

Admit the *side* of the *Square* at the *end* be AC 16 *Inches*, and the *length* thereof 14 *foot*, Then

By the *Line* of *Numbers.*

Extend the *Compasses* always from 12 *Inches* unto the *side* of the *Square* AC 16 *inches*; the same *distance* will reach from the *length* 14 *foot* turned twice over unto 24 $\frac{8}{16}$ *feet* in the *Piece* of *Timber.*

The *Arithmetical* way.

$\frac{AC\,16\,q \times BD\ 14\ foot.}{144} =$ The *Content* in *Feet* $24\frac{8}{16}$

Probl. V.

How to Measure Round-Timber *five several ways.*

ADmit you were to *Measure* a *Piece* of *Round-Timber*, as a *Tree* whose *Diameter* or *thickness* at the *end* is 20 *inches*; I desire to know how many *inches* in *length* will make one *foot* of *Timber.*

By the *Line* of *Numbers.*

Extend the *Compasses* from the *Diameter* AB 20 *inches* unto the constant *Number* 13, the same *distance* will reach from the same 13 turned twice over unto $5\frac{1}{3}$ *inches* for one *foot*, as AD.

The *Arithmetical* way. $\frac{2220}{AB\,q} =$ AD $5\frac{16}{120}$ *inches* for one *foot*.

Having the *Diameter* of a *Piece* of *Timber*, as admit it to be 20 *inches*, and the *length* suppose 15 *foot*; To find the *Contents* in *feet.*

By the *Line* of *Numbers.*

Extend the *Compasses* always from $13\frac{14}{15}$ to the *Diameter* AB 20 *inches*, the same *distance* will reach from 15 the *length* turned twice over unto the *Contents* $32\frac{7}{15}$ *feet* in the *tree.*



The

The *Arithmetical* way.

Square the *Diameter* AB 20, and it is 400; treble it by 3, and it is 1200, *multiply* it by the *length* 15, and the *Product* is 18000, that *divide* by 550, and the *contents* is 32 $\frac{717}{1000}$ *feet* of *timber* in a *round piece* or *tree*, which is 32 *foot*, and about $\frac{1}{4}$ *quar.*

Here is likewise another brief Rule, *Arithmetically* thus.

Square the *Diameter* AB 20, and it will be 400; *Multiply* that by 11, and it is 4400, *divide* it by 14, and the *Quotient* is 314, and 4 *remains*, which *multiplyed* by the *length* 15, the *Product* is 4714; that *divide* by 144, and the *Quotient* is 32 $\frac{1}{10}$ as before.

Or else you may find the *Contents* of the *Circle* by this Rule, as 7 is to 22, so is the *Diameter* to the *Circumference*; or *multiply* half the *Diameter* by half the *Circumference*, and the *Product* is the *Content* of the *Circle*; that *Multiply* by the *length*, and *divide* by 144, gives the *Content* of the *Timber* or *Tree* in *feet* or *parts*.

Now the common way used by Artificers, is to *measure* round a *Piece* of *Timber* or *Tree*, and to take the one fourth part for the *Square*, which is very erroneous and false.

For Example.

The *measure* of the *Compass* or *Circumference* by the Rule before-going is 62 $\frac{2}{10}$ *inch.* of the *round piece* of *timber* or *tree* the $\frac{1}{4}$ thereof is 15 $\frac{20}{200}$ *inches*, which they take to be the *Square*; which *Multiplyed* into it self, produceth 243: 66 for the *Area* of the *Base*; which *Multiplyed* by the *length* 15 *foot*, the *Product* is 3649490, the *Contents* in *feet* and *parts*; that *divided* by 144, the *Quotient* is 25 $\frac{121}{1000}$ that is differing from the Truth no less then 7. $\frac{376}{1000}$, that is, 7 *foot* and about a *quarter* too much: the Buyer hath then his due; but I conceive they agree in the *Price* to stand to that *measure*, by reason of the wast in Chips before it is brought into *Squares*; but the best way will be to *measure* the *tree* right, and afterwards allow for the Wast; or else in time the Error will be taken for Truth, and Truth will be accounted Error, as it is by too many this day.

How to Measure *a* Round piece *of* Tapering Timber.

Admit the *Diameter* of the Great *End* of a *piece* of *tapering timber* be AB 20 *Inches*, and the Lesser *End* CD 16 *Inches*, and the *length* EF 15 *foot*. To find the *Contents*, *add* both the *Diameters* 20 and 16, the *Sum* is 36, the *half* is 18 for the *Mean*.

Then *Extend* the *Compasses* always from 13 $\frac{14}{100}$ to the *Mean-diameter* 18, the same will reach from the *length* 15 *foot* turned twice over unto 26 $\frac{11}{100}$ *foot*. Or by *Arithmetick*, *Square* 18 the *Mean-diameter*, and it makes 324; that treble by 3, the *Product* is 972; that *Multiply* by the *length* 16, the *Product* is 14586, that *divide* by 550, and the *Quotient* is 26 $\frac{11}{100}$ *foot*, the *Contents* of the *taper-piece* of *timber* is 26 *foot* and half.

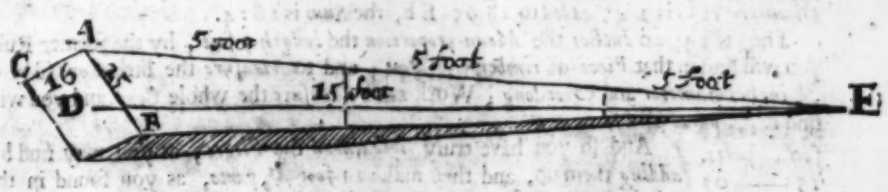
PROBL. VI.

How to Measure *a* Pyramedal piece *of* Timber.

This *piece* of *timber* is *measured* by this Rule, (*viz.*)

A right Lined sharp Piece of *Timber* is called a *Pyramide*

ADmit you have a *piece* of *timber* to *measure*, whose *length* at the *Base* is 25 *inches* AB, and *breadth* AC 16 *inches*: and the *length* of the *piece* DE 15 *foot*.



By the *Line* of *Numbers*.

First, by the *Line* of *Numbers* find a *Mean-proportion* between 25 and 16 by *dividing* it into 2 *parts*, and the *middle* will fall upon 20 *inches*, the *Mean-proportion* required.

Then extend the *Compasses* always from 20 $\frac{78}{100}$ unto the *Mean-diameter* 20 *Inch.* the same *distance* will reach from the *length* 15 *foot* turned twice over unto 13 $\frac{888}{1000}$ *foot* of *timber.*

The *Arithmetical* way.

$$\frac{AB \times AC \times DE}{432} = 13 \text{ foot } \frac{888}{1000} \text{ parts of timber in the Piece.}$$

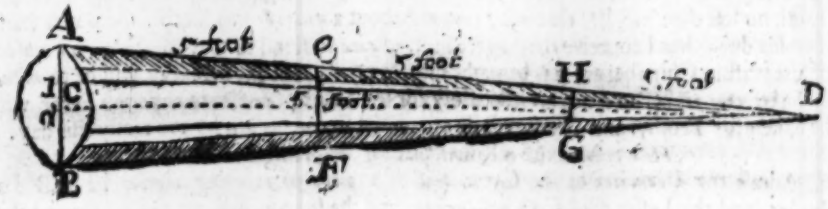
$$\frac{AB \times AC \times \frac{1}{4} DE}{144} = 13 \text{ foot } \frac{888}{1000} \text{ parts, that is 13 foot and above three quarters.}$$

Prob. VII.

How to Measure *a* Conical piece *of* Timber.

Admit you had a *Cone Piece* of *timber* whose *Base* or *Diameter* at the *End* AB is 28 *inches,* and the *length* thereof CD 15 *foot,* it is required to know how many *feet* of *timber* is in the *Piece.*

But the *Base* thereof *Round* it is a *Cone.*



Extend the *Compasses* always from 23 $\frac{48}{100}$ unto the *Diameter* AB 28, the same *distance* will reach from the *length* 15 *foot* turned twice over unto 21 $\frac{4}{15}$.

The *Arithmetical* way.

$$\frac{ABq \times CD}{550} = 21 \frac{18}{100} \text{ foot of timber in the Cone Piece.}$$

And by the former Rule you may *Measure* any part of a *Cone* or *Pyramide-piece.* Admit you were to cut a *Piece* of 5 *foot* at the greater *End,* and you find the *Diameter* EF 18: 95 *Inch.* First, *Mean-diameter* 18: 95 and 28 *Inch. added* is 46; 95 the half is 23: 48 the *Mean*: then extend the *Compasses* from 13 $\frac{14}{100}$ unto the *Mean-diameter* 23 $\frac{48}{100}$; the same *distance* twice repeated from the *length* 5 *foot,* will reach to 15 $\frac{77}{100}$ *foot* in the $\frac{1}{3}$ of the *Cone* at the great *End*; And likewise to *Measure* EFHG the *Diameter* HG is 9. 45 *added* to 18. 95 EF, the *Sum* is 28: 4.

The $\frac{1}{3}$ is 14; 20 *Inches* the *Mean-proportion* the *length* 5 *foot*; by the former Rule you will find in that *Piece* of *timber* 5 $\frac{42}{100}$ *foot*; and to *Measure* the little *Cone* GH 9 $\frac{41}{100}$ *inches diameter* and 5 *foot long*; Work as to *Measure* the whole *Cone,* and you will find it $\frac{81}{100}$ *parts* of a *foot.*

foot.	*parts.*
15	07
5	50
0	81
21	38

And so you have truly *Measured* the *Pieces,* as you may find by *adding* them up, and they make 21 *foot* $\frac{38}{100}$ *parts,* as you found in the whole *Cone* at first; and so by finding the *Area* of the *Circle* and $\frac{1}{4}$ *part,* you may find the *Segment* of any *Cone* or *Pyramide* that is *Square* in the *sides* by the *Area* thereof; by the same Rules you *Measure Stone.* It is needless to make more *Examples* in this thing.

CHAP. X.

CHAP. X.

For the Burden *of a* Ship, *or her* Tunnage, *Take theſe* Rules *following.*

SECT. I.

SUppoſe you were to *Gage* a *Ship* that the *length* of her *Keel* is 45 *foot*, the *breadth* of the *Beam* 17 *foot*, the *depth* of her *Hould* 9 *foot* always to find the *Tunnage.*

Multiply the *breadth* by the *length*, and with the *Product Multiply* the *depth* in *Hold*, and *divide* by 100, and the *Quotient* will ſhew you the *Tunnage* to be in this *Example* $68\frac{85}{100}$ *tun.*

Or extend the *Compaſſes* always from 100 to 17 the *breadth*, the ſame *diſtance* will reach from 45 the *length*, to $7\frac{65}{100}$.

Then extend the *Compaſſes* from 1 unto $7\frac{65}{100}$, and the ſame *diſtance* will reach from the *depth* in *Hold* 9 *foot* to the *tunnage* $68\frac{85}{100}$ *tun* of *King's tunnage.*

But for *Merchants Ships* who give no allowance for *Ordnance*, *Maſts*, *Sails*, *Cables*, and *Anchors*, which is all a Burden, and no *tunnage*

You muſt ſtork thus for the *tunnage.*

SECT. II.

$$\frac{45 \times 17 \times 9}{95} = 72\frac{45}{100}$$ *Tun* Burden.

Or, extend from the *Gage-point* 95 always to the *length* of the *Keel* 45, the ſame will reach from the *breadth* 17 of the *Beam* to 24 *Number*, as to $8\frac{1}{10}$; then extend from 1 to $8\frac{1}{10}$ the ſame *diſtance* will reach from the *depth* in *Hold* 9 *foot* to the Burden $72\frac{45}{100}$ *tun.*

SECT. III.

Having the Proportion *of any one* Ship *in Burden, with the* length *of her* Keel-Timbers; *To Build another of any Burden according to that.*

PROPORTION.

ADmit I have a *Ship* of 80 *Tun*, the *length* of her *Keel* is 46 *foot.* Now I am to Build a *Ship* whoſe *Keel* muſt be 65 *foot*; I deſire to know how many *Tun* ſhe muſt be.

Extend the *Compaſſes* from 46 *foot* unto 65 *foot*, the ſame extent will reach from the Burden 80 *Tun*, being turned 3 times over unto $225\frac{7}{10}$ *tuns.*

The *Arithmetical* way.

$$\frac{80 \text{ X} : 65}{46\ \text{C}} = 225 : \frac{7}{10}\ \textit{tuns.}$$

SECT. IV.

Sect. IV.

ADmit you had a *Ship* of 226 *tuns*, and the *length* of her *Keel* is 65 *foot*; Now I would Build a *Ship* of twice the Burden, that is 452 *tuns*; Now I would deſire to know the *length* of her *Keel*.

Extend the *Compaſſes* from 226 unto 452, the $\frac{1}{2}$ of that *diſtance* will reach from the *length* of her *Keel* 65 *foot* unto the *length* of the greater *Ship's Keel* 81 $\frac{2}{10}$ *foot* ferè.

The *Arithmetical* way.

$$\frac{65.\ C.\times 452}{226} = 81\ \tfrac{1}{10}\ \textit{foot ferè.}$$

I could have inſiſted upon more *Examples*, but it is to no purpoſe; by reaſon the *Carpenters* have theſe Rules in Practice moſt of them; and for *Gaging* and *Meaſuring Ships*, the *breadth* and *ſharpneſs* of her *bottom* is to be conſidered; and to abate ſomething of 95 the *Divizer*, or *add* ſomething to it according to Judgement and Reaſon; and ſo likewiſe to 100, to find the *tunnage*.

Chap. XI.

The Application of the Line *of* Numbers *in Common Affairs, as in* Reduction *of* Weight *and* Meaſure *of* Cheeſe, Butter, *and the like.*

I Have *added* this Chapter, not for that I think it abſolutely neceſſary; but only becauſe I would have the abſolute applicableneſs of the Rule to any thing be hinted at, that it may be known; that any thing may be *meaſured* by *Rule*, as well as by *Weight*, ſo far as there is Proportion conſidering that, and any thing elſe; the Application of which I leave to the Induſtrious Practitioner, only here I give a hint.

What have been ſaid of other things in *Reduction*, is general in any other, as from 12 to 10 either *Shillings* or *Inches* to tenths, as of a *Shilling*, or tenths of a *Foot*, or *Pence* or *Farthings*, *Ounces* or *Chauldrons*, *Hundreds*, either *weight* or *tale*. The Rule is thus, (*viz.*) In either one *ſhilling*, or *foot*, *hundred*, or the like. If 100 is 12 *d.* what ſhall 66 be? *facit* 8 *pence* or 8 *Inches*; that is, Extend the *Compaſſes* from 100 to 12, the ſame will reach from 66 to 8; and ſo of all other.

If 100 be 112 *P.* what ſhall 50 be? *facit* 66 *Pound*; If 100 be 8 *Pints*, what ſhall 25 be? *facit* 2 *Pints*; If 100 be 48 *farthings*, what ſhall 30 be? *facit* 14.4, that is 3 *d.* 2 *f.* $\frac{1}{5}$ near.

If 100 be 36 *buſhels*, what ſhall 24 be? *facit* 8 *buſhels* $\frac{1}{3}$ and better.

If 100 be 60 *min.* what ſhall 50 be? *facit* 30 *min.* or $\frac{1}{2}$ an *hour*.

If 100 be 110, what ſhall 80 be? *facit* 96. The like is for any Line of *Reduction*. Now if you would know how many there muſt be in any greater Number then one; then ſay, By the *Line* of *Numbers* thus: If 48 *farthings* be one *ſhilling*, how many *ſhillings* is 144 *farthings*? *facit* 3 *ſhillings*. For the extent from 48 to 1, will reach from 144 to 3. And again, if a *Mark* and a *half* be one *Pound*, how many *Pound* is 12 *Mark*? the extent from 1:50 to 1 ſhall reach from 12 to 8; which reaſon muſt help you to call it 8 *Pound*. Again, if 3 *Nobles* be one *Pound*, what is 312 *Nobles*? *facit* 104 *l.* the extent from 3 *N.* to 1 *P.* will reach from 312 to 104: Further, if 2 *Chauldron* of *Coles* coſt 36 *ſhill.* what ſhall $\frac{1}{2}$ a *Chal.* coſt? *facit* 18. But more to the matter; If 36 *buſhels* coſt 30 *s.* what ſhall 5 *buſh.* coſt? *facit* 4 *s.* 2 *d.* If one *week* be 7 *days*, how many *days* in 39 *weeks*? as 1 to 7, ſo 39 to 273 *days* in 39 *weeks*; As 8 *furlongs* make 1 *mile*, how much is 60 *furlongs*? *facit* 7 $\frac{1}{2}$ *miles*, for the extent from 1 to 8, gives from 60 to 7:50, and the like of all other.

CHAP. XII.

The moſt Excellent

Gunners Scale,

Which reſolves the Chief Principles of the whole Art *of* Gunnery, *in a very brief and Compendious form, never by any ſet forth in the like nature before; with divers* Excellent Concluſions *both* Arithmetical, *and* Geometrical, *and* Inſtrumental; *and by* Tables *being framed both with, and without the help of* Arithmetick. *As alſo divers* Artificial Fire-Works, *both for* Recreation, *and for* Sea *and* Land-Service.

SECT. I.

The Qualifications every Gunner *ought to have, and the* Properties, Duty, *and* Office *of a* Gunner.

HE ought to have skill in *Arithmetick*, to work any Concluſion by the ſingle and double *Rule* of 3, to abſtract both the *Square* and *Cube Roots*, and to be perfect in the *Art* of *Decimal Arithmetick*, and to be skilful in *Geometry*; to the end he may be able through his knowledge in theſe *Arts*, to *meaſure heights*, *depths*, *breadths* and *lengths*; and to draw the *Plot* of any *Piece* of *Ground*, to make *Artificial Fire-Works* which are uſed in the time of *War*: A *Gunner* that hath a Charge ought to have in readineſs all neceſſary things for his *Artillery*:

As *Wheels*, *Axle-trees*, *Ladles*, *Rammers*, *Sheep-skins* to make *Spunges*, *Gun-powder*, *Shot*, *Tampions*, *Chain-Shot*, *Croſs-bar-ſhot*, *Canvas*, or *Strong Paper* to make *Cartredges*, *Fire-works*, *Artificial Torches*, *Dark Lanthorns*; again, to *Mount* and *Diſmount Guns*, *Hand-ſpikes*, *Coyns*, *Budge-Barrels* to carry *Powder*, and *Baskets* to carry *Shot* to your *Piece*. When leiſure will permit, he is to chooſe good *Match-cords*, to *Arm* his *Linſtocks* in readineſs to light, for to give *Fire*, and alſo a pair of *Caleper Compaſſes* to *meaſure* the *Diameters* of *Shot*, or the *Muzzle*, or *Baſe-ring*, or the like; and alſo a ſmall *Braſs* pair of *Scales* and *Weights*, a *Ruler* divided into *Inches*, and 8 *Parts* in every *Inch*, for the ready *meaſuring* of *Cartredges*, how to fill them.

A *Gunner* ſhould never be without ſuch a *Scale* as this as I have here deſcribed, and to know the Uſe thereof perfectly; and thereby be ready to give a reaſonable anſwer to any Man of any Queſtion belonging to any ſort of *Ordnance* uſed in *England* in a moment, as this *Scale* will do, as ſhall be ſhewn: He ſhould always carry a pair of *Compaſſes* with him to *meaſure* the *Diameter* or *Bore* of any *Piece*; and alſo the *length* of the *Cylinder* within, the better to fit her with a *Shot*, and proportion a *Charge*.

A *Gunner* ought to know the *Names*, *Length*, *Weight* and *Fortification* of every *Piece* about the *Chamber* (that is as far as the *Piece* is *Laden* with *Powder*;) and be able to tell readily how much *Powder* is a due *Charge* for any *Piece*, what *Shot* is fit, how many *Matroſſes* muſt attend the ſame, how many *Horſes* or *Oxen* will draw the ſaid *Piece*, or *Men*, if occaſion be; He muſt be careful in making Choice of a ſober honeſt Man, for the *Yeoman* of the *Powder*; and he muſt not beat up the Head of his *Powder-Barrels* with an *Iron tool*, but with a *Wooden Mallet*, which can never Fire the ſame: A *Gunner* ought to trie his *Piece*, to know whether it be true *bored* or not, to proportion his *Charge* according to the thinneſt ſide of the Metal, and accordingly take his Obſervation at the *Britch* of the *Piece*, juſt over, where by his *Art* he finds the middle of the *Bore* within the *Piece* is; by which means a good *Shot* may be made out of a bad *Piece*.

Before he makes a *Shot*, he is to conſider, that if the *Piece* lie point blank, or under Metal, he ought to put in a ſufficient *Wadd* after the *Shot*, to keep it cloſe to the *Powder*; for if it ſhould not be cloſe, but ſome diſtance between the *Powder* and *Shot*, the *Piece* will break in the vacant place; but in caſe you *mount* your *Piece*, put no *Wadd* after the *Shot*.

And one chief thing is to know very well how to *Diſport* his *Piece*, be it either true *bored*, or not true *bored*, which he may try firſt.

When a fit Man is entertained, the Mr. *Gunner* (whom he ſerves,) ſhould bring him to his *Pieces*, and give him the Denominations of his *Piece*, and parts thereof; which when he hath learned, which is the *baſe-ring*, and *trunnion-ring*, the *muſſel-ring*, and the like, (you may ſee their names all plain in the Fig. of the *Gun* without more words;) and likewiſe the *Crown*, *Handſpike*, the *Coyn*, and the like; and how far in the *Bore* is called the *Chamber* of the *Piece*: Theſe things, with the *Gunner's* care well underſtood, he may give them further Directions, (*viz.*) But it is great pity, that the *Gunners* at *Sea* did not exerciſe the *Sea-men* in this knowledge, as the *Corporal* doth in Muſtering of them with their *Muſquets*; for want of the like knowledge, the greateſt part of common *Sea-men*, are as dull and ignorant, when they be required to ſtand by a great *Gun* in time of *Fight*; and therefore it would be much for the Credit and Honour of our *Engliſh* Nation, to train up their *Sea-men* in this knowledge eſpecially; but it is taken notice of, that if any man have any *Art* above another, he is afraid to let another ſee him do any thing, or underſtand from him ſuch knowledge, for fear he will be in a ſhort time as able as himſelf; which many do attain unto in a ſhort time to be as able as himſelf without their help; therefore it is more for their Credit to teach them what they know.

Sect. II.

Who were the Inventors of Gun-powder, *and ſome Principles of* Philoſophy *fit to be known.*

SOme *Italians* have writ that *Archimides* the Philoſopher was the firſt Inventor of *Guns* and *Gun-powder*: or whether this be truth or not, Learned Men are of divers minds; *Munſter*, and *Gilbert Cognot* have written, that *Guns* were deviſed firſt in the year 1370 by a Monk, whom *Munſter* calls *Bertholdus*, ſithen our Country man Dr. *Dee* in his *Mathematical Preface*, and *Diſcourſe* of *Menader* ſaith, that an *Engliſh-man* was firſt Inventor of *Gun-powder* in another Country, and they firſt made uſe of it from him; alſo our *Engliſh* Chronicles do report, that in the year 1380 a *Monk* did accidentally let fall a ſpark of Fire upon *Brimſtone* and *Salt-peter* beaten to Powder in a Morter covered with a *Slat-ſtone*, he ſeeing this mixture blow off the Stone from the Morter, did thereupon deviſe a kind of *Powder*, and taught the *Venetians* how to uſe the ſame in Pipes of Iron againſt the *Gallyaſſes*.

Every Simple Body is either Bright and Light, or elſe Groſs and Dark, and Ponderous, and according to the variety and difference, it is always naturally carryed towards ſome one or other part; the World hath *height* as upwards, or *depth* as downwards; and the *depth* dependeth upon the Influence of the *heights*.

All

All pure and rare bodies aſcend, as the Fire more than the Ain; but the thick and groſs bodies deſcend, as the Earth more than the Water.

Nothing worketh naturally, but in that which is contrary to it, and more feeble; the form working, is aided by the Qualities; and the matter ſuffering, which ſuffereth by the Quantity.

Nature is extremely curious, as well of her perfection, as her conſervation; and then when all things conſpire, as well the Action that cometh from the Agent, as the Paſſion from the Patient, hath proportion.

Accident hath its variety from the Subject, and goeth not from one thing unto another.

Every Corporal thing repoſeth in its natural place: Motion may be made any where within the Orb of the Moon, Nature admitteth no Empreſs.

A body rarifying it ſelf, the place thereof increaſeth as the body increaſeth, the reſiſtance of the moved proportion to the Mover, furthereth the motion; the longer the Chace of a *Piece*, the louder the Report; alſo the force of the ſtroke dependeth on the ſwiftneſs of the Courſe.

SECT. III.

The Deſcription *and* Uſe *of the* Gunners Scale, *upon which is all ſorts of* Ordnance, *from the* Canon, *to the* Baſe *of their* Weight, Lading, Shot, *and all other things appertaining to them.*

THis *Scale* is made according to the *Diameter* of our *Engliſh Ordnance*, but 8 *inch. long*, the *Diameter* of a *Canon-Royal*; and it may be made of Silver, Braſs, or Box, or any other fine grained Wood, that will not warp. Upon one ſide I have ſet the Names of all ſorts of *Ordnance*, and in the *Angle* of meeting with the Names, is the *diameter* of the *bore*; and betwixt that and the next leſs *diameter*, is firſt the common *length* of ſuch *Pieces*; and upon the ſtep of *breadth*, is how many Paces theſe *Pieces* ſhoot point blank, and right in the *Angle* of meeting, betwixt the two *diameters* with the *Angle* of meeting with the Names, is firſt the *weight* of the *Gun*, the *breadth* of the *Ladle*; and thirdly, the *length*; fourthly, the *weight* of the *Charge* in *Powder*; fifthly, the *diameter* of the *Shot*; ſixthly, the *weight* of the *Shot*; ſeventhly, a *Line* of *Inches*; eighthly, each *Inch* divided into 10 *parts*, and likewiſe into 8 *parts*, which are *parts* and half *quarters*, which the *Line* of *Diameters* of the *bore* comes from. The *degrees* in the *diviſions*, and on the *thickneſs* and *length* thereof, there is a *Line* of *Numbers*, by which you work all the moſt uſeful Queſtions in *Gunnery*, as you will find in the following page.

The Uſe of this *ſide* is thus.

Suppoſe you come to a *Piece* of *Ordnance*, and it is deſired to know what *Piece* it is, take the *Scale*, and put it into the *bore* of the *Piece*, mark the *ſtep* of a *Diameter* that fits it, and the *Angle* of *Diameter* goes down into the *Line* of *Inches*, and *parts*, and that *diameter* goes into the *ſide* in the *Angle* of meeting, and tells you the Name of the *Piece*: Betwixt the next leſs *Diameter*, right under, you have as before, the common *weight* of the *Piece*, the *breadth* and *length* of the *Ladle*, weight of *Powder*, *diameter* of *Shot*, and *weight*.

As for Example.

Admit I came to a *Gun*, and found by the former directions, that her *diameter* of the *bore* is $4\frac{1}{2}$ *Inches*. And in the *Angle* of *meeting* in the *ſide*, I find her Name is *Demi-culvering*, lower then ordinary; at the *end* thereof I find 9 or 10 *foot* the uſual *length*, and betwixt the next leſs *diameter* and the *ſtep* is 174 the *paces* the *Piece* carries the *Bullet* in a *level-line*, point blank, right againſt *weight* in the next leſs *Diameter*, which is $\frac{1}{4}$ *Inches*, is the uſual *weight* 2000 *l.* *breadth* of the *Ladle* 8, and *length* 12 *Inches*, the *weight* of the *Powder* $6\frac{1}{2}$ or 4 *ounces*; and next the *diameter* of the *Shot* 4 *Inches*; and next, the *weight* 9 *l.* So that you ſee the next leſs *diameter* is the *diameter* of the *Shot*, as well as of a leſs *Piece* of *Ordnance*. This I have made plain to the meaneſt capacity: Here they are ſet down in this *Table* following.

The Explanation of the Scale may serve likewise for the *Table*; only take notice, that under *Inches* and *Parts*, is to be understood the first; to the *left hand* is *Inches*, and the other is so many 8 *parts* of an *Inch*.

As for Example.

Admit you enter the *Table* with a *Saker* of the lowest sort, the *height* of the *bore* is 3 $\frac{5}{8}$ *Inches*, 8 *foot long*, the *weight* 1400, *breadth* of the *Ladle* 6 $\frac{5}{8}$, *length* 9 $\frac{1}{4}$ *Inch*. *weight* of the *Powder* 3 *pound* 6 *ounces*, *diameter* of the *Shot* 3 $\frac{5}{8}$, *weight* of the *Shot* 4 *pound* 12 *ounces*, and the *paces* the *Piece* carries, by *Alex. Bianco's Tables* is 150 of 5 *foot* to the *Piece*.

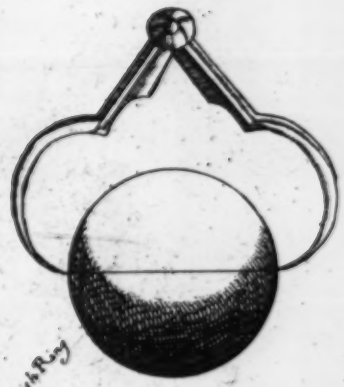
Observe that the *Ladle* is but 3 *diameters* of the *Shot* in *length*, and $\frac{1}{2}$ *parts* of the *Circumference* from the *Canon*, to the whole *Culvering*; I allow the Charge of *Powder* to be about two *diameters* of the *Piece*: from the *Culvering* to the *Minion*, the Charge to fill two *diameters* and a half; all from the *Minion* to the *Base* three *diameters* of *Powder*.

The names of the *Pieces* of *Ordnance*.	Diameter of the Bore.	Length of the Gun.	Weight of the Gun in pounds.	Breadth of the Ladle.	Length of the Ladle.	Weight of the Powder.	Diameter of the Shot.	The weight of the Shot.	He shoots point blank.
The	Inches. Parts.	Feet. Inches.	Pounds	Inches. Parts.	Inches. Parts.	Pounds. Ounces.	Inches. Parts.	Pounds. Ounces.	Paces.
	L 8	L 8		L 8	L 8		L 8		
A Base.	1 : 2	4 : 6	200	2 : 0	4 : 0	0 : 8	1 : 1	0 : 5	60
A Rabanet.	1 : 4	5 : 6	300	2 : 4	4 : 1	0 : 12	1 : 3	0 : 8	70
Fauconets.	2 : 2	6 : 0	400	4 : 0	7 : 4	1 : 4	2 : 2	1 : 5	90
Faucons.	2 : 6	7 : 0	750	4 : 4	8 : 2	2 : 4	2 : 5	2 : 8	130
Ordinary Minion.	3 : 0	7 : 0	$\frac{7}{10}$	5 : 0	8 : 4	2 : 8	2 : 7	3 : 4	120
Minion of the largest size.	3 : 2	8 : 0	1000	5 : 0	9 : 0	3 : 4	3 : 0	3 : 12	125
Saker the lowest sort.	3 : 4	8 : 0	1400	6 : 4	9 : 6	3 : 6	3 : 2	4 : 12	150
Ordinary Sakers.	3 : 6	$\frac{5}{8}$: 0	2500	6 : 6	10 : 4	4 : 0	3 : 4	6 : 0	160
Sakers of the oldest sort.	4 : 0	10 : 0	1800	7 : 2	11 : 0	5 : 0	3 : 6	7 : 5	163
Lowest Demiculvering.	4 : 2	10 : 0	2000	8 : 0	12 : 0	6 : 4	4 : 0	9 : 0	174
Ordinary Demiculvering.	4 : 4	$\frac{10}{12}$: 0	2700	8 : 0	12 : 6	7 : 4	4 : 2	10 : 11	175
Elder sort of Demiculvering.	4 : 6	$\frac{11}{12}$: 0	3000	8 : 4	13 : 4	8 : 8	4 : 4	12 : 11	178
Culverings of the best size.	5 : 0	$\frac{12}{12}$: 0	4000	9 : 0	14 : 2	10 : 0	4 : 6	15 : 0	180
Ordinary Culvering.	5 : 2	$\frac{13}{12}$:	4500	9 : 4	16 : 0	11 : 6	5 : 0	17 : 5	181
Culvering of the largest size.	5 : 4	$\frac{14}{12}$: 0	4800	10 : 0	16 : 0	11 : 8	5 : 2	20 : 0	183
Lowest Demicanon.	6 : 2	11 : 0	5400	11 : 4	20 : 0	14 : 0	6 : 0	30 : 0	156
Ordinary Demicanon.	6 : 4	12 : 0	5600	12 : 0	22 : 0	17 : 8	6 : $\frac{1}{2}$	32 : 0	162
Demicanon of great size.	6 : 6	12 : 0	6000	12 : 0	22 : 6	18 : 0	6 : 5	36 : 0	180
Canon Royal, or of	8 : 0	12 :	8000	14 : 6	24 : 0	32 : 8	7 : 4	58 : 0	185

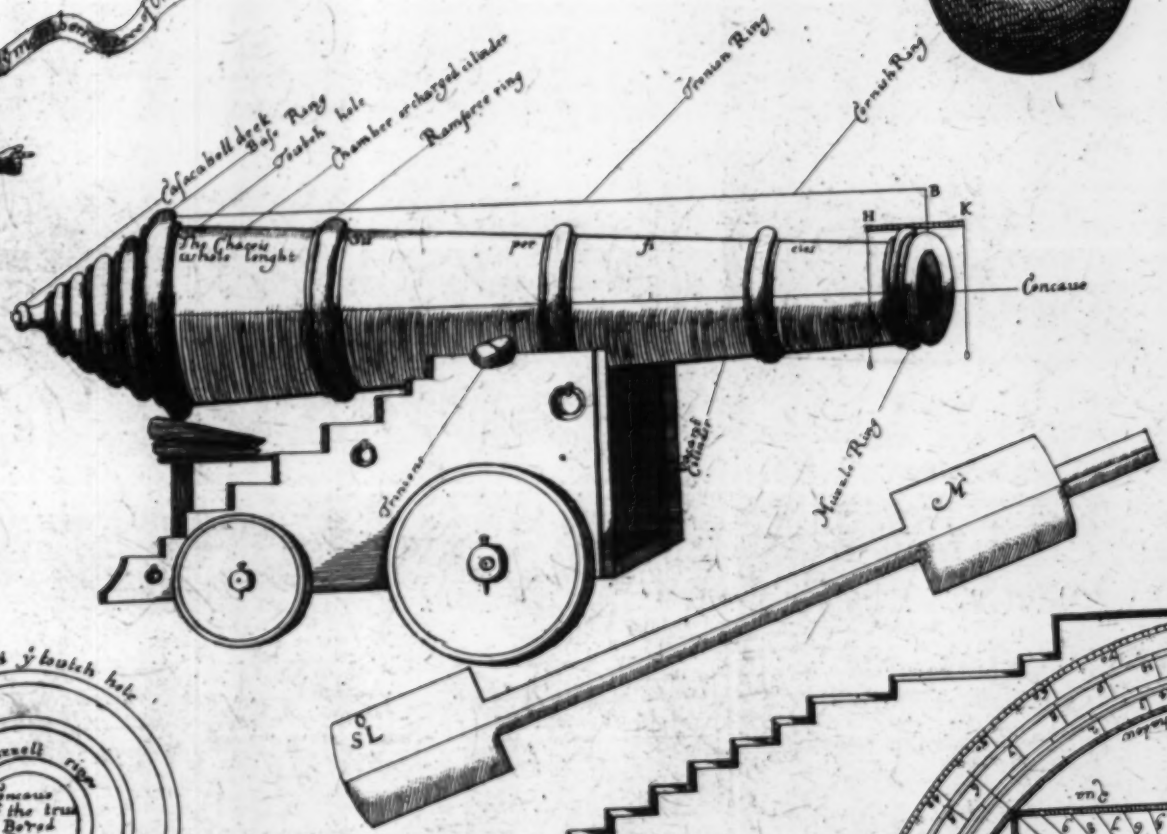
The Description of the other side of my Gunner's Scale.

Upon the other side is a *Scale* of 8 *Inches* divided into four *quarters*, and betwixt each *quarter* above it is three *Columns*; the *Inches* shews the *height* of all sorts of *Iron shots* from 2 *ounces* to 72 *pound*; and of *Lead* from 3 *ounces* to 806 *pound* $\frac{1}{2}$, and of *Stone* from 1 *ounce* to 26 $\frac{12}{16}$ *pounds*; each distinguished from other by their names, written in the first *Inch*, the *Table* is in the sixth *Section*, and the *weights* and *measures*, accommodated into our English *Averdupois* weight of 16 *ounces* to the *pound*, and to our *Foot* of *Assize* of 12 *Inches* to the *Foot*. The *Line* of *Inches* being likewise divided into 10 *parts*, the whole into 80, may serve for 800; for *Protraction* as follows: There is also the *Gunners Quadrant* divided into 90 *degr.* in the outmost Limb, and in the second Limb within, is divided into the 12 *points* of the *Gunner's Quadrant*, and each



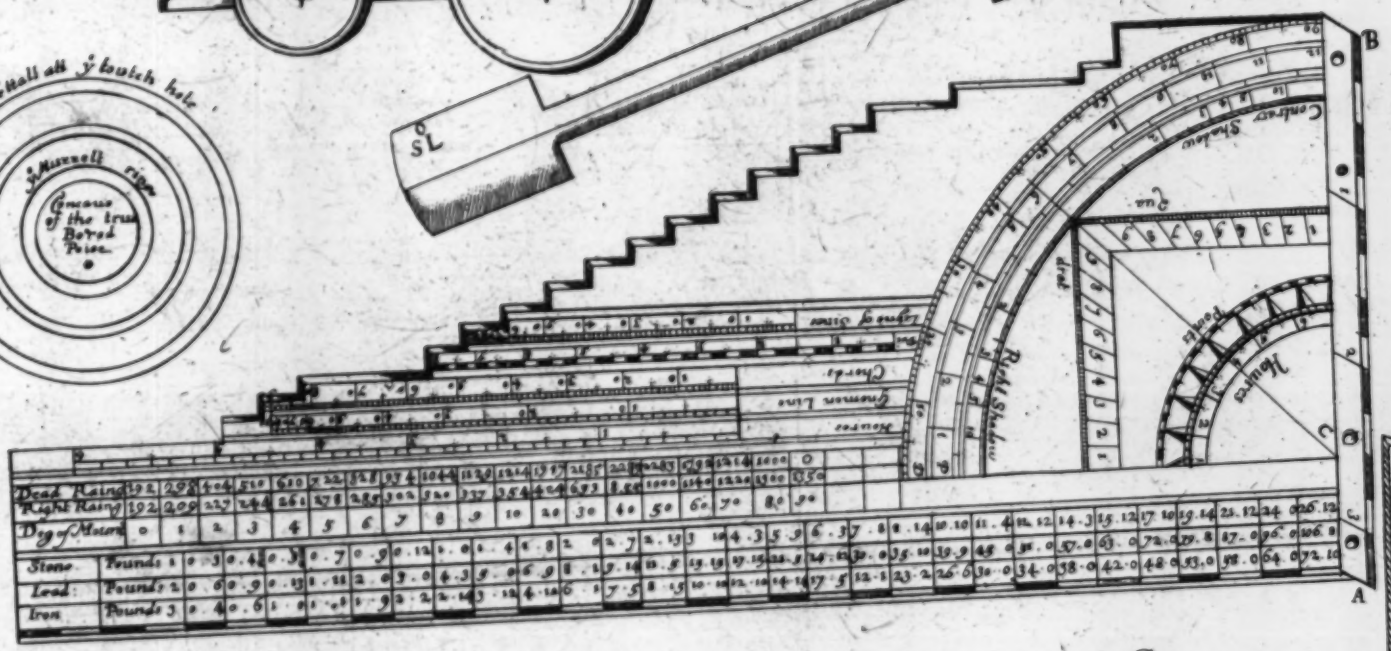




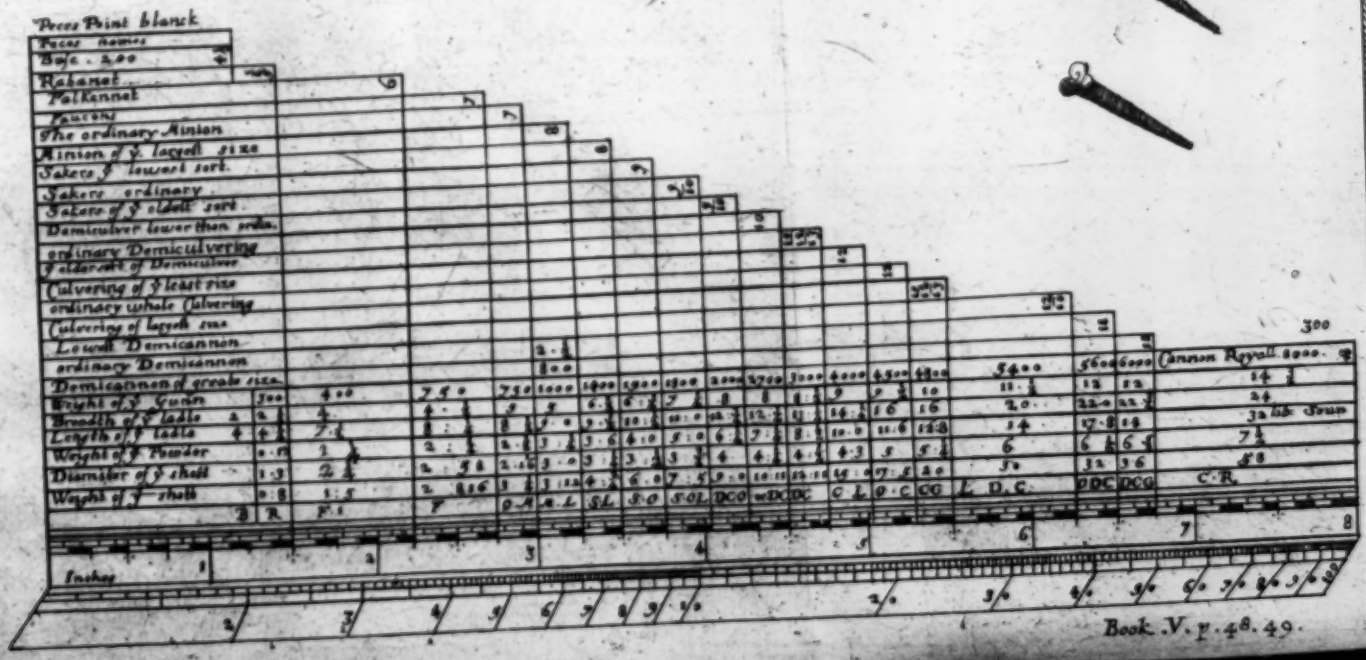

Cascabell brek
Base Ring
Touch hole
Chamber or charged cilinder
Rampere ring
Fronon Ring
Cornish Ring
The Chase
whole lenght
Concave
Trunions
Mizzel Ring


d
c
b
a


Thes Nr Hall all ye touch hole
ye Muzzell ring
Concave of the true Bored Peice


B
A
Contrary Shadow
Quadrant
Right Sights
Hours
Dead Range 192 208 224 240 260 278 288 302 320 337 354 429 673 856 1000 1140 1320 1500 1650 1800 0
Right Range 192 208 227 244 261 278 288 302 320 337 354 429 673 856 1000 1140 1320 1500 0 0 0
Degs of Mettle 0 1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90
Stone Pounds 1 0 .3 0 .4 0 .5 0 .7 0 .9 0 .12 0 .0 0 .4 0 .8 2 0 2 .7 2 .13 3 .10 4 .3 5 .9 6 .17 8 .0 9 .14 10 .10 11 .4 12 .12 14 .3 15 .12 17 .10 19 .16 21 .12 24 .0 26 .12
Lead Pounds 2 0 .6 0 .9 0 .13 1 .11 2 .0 3 .0 4 .3 5 .9 6 .9 8 .2 9 .14 11 .5 13 .15 15 .10 17 .15 20 .5 22 .15 25 .10 28 .0 30 .10 33 .9 36 .5 39 .0 42 .0 45 .0 48 .0 51 .0 54 .0 57 .0 63 .0 72 .0 79 .8 87 .0 95 .0 106 .8
Iron Pounds 3 0 .4 0 .6 1 .0 1 .0 1 .9 2 .2 2 .14 3 .12 4 .14 6 .1 7 .5 8 .15 10 .10 12 .10 14 .14 17 .5 19 .1 23 .2 26 .6 30 .0 34 .0 38 .0 42 .0 48 .0 53 .0 58 .0 64 .0 72 .12




Peces Point blanck
Pecces names
Base 200 ℔
Rabanet
Falkannet
Falcon
The ordinary Minion
Minion of ℔ largest size
Sakers ℔ lowest sort.
Sakers ordinary
Sakers of ℔ eldest sort
Demiculver lower then ordin.
ordinary Demiculvering
℔ eldest of Demiculver
Culvering of ℔ least size
ordinary whole Culvering
Culvering of largest size
Lowest Demicannon
ordinary Demicannon
Demicannon of greate size
Weight of ℔ Gunn
Breadth of ℔ ladle
Length of ℔ ladle
Weight of ℔ Powder
Diamiter of ℔ shott
Weight of ℔ shott
Cannon Royall 8000 ℔
Inches
Book. V. p. 48. 49.

each *point* 4 *parts*; and in the third Limb is a *Geometrical diviſion* of right and contrary ſhadows, for the ready taking of *heights* and *diſtances*; but there is alſo a *Geometrical Quadrate*, with each *ſide* divided into 10 *parts*, which ſtands for 100, and each 10 *parts* divided into 10 more, the Uſe thereof in taking of *heights* and *diſtances* is in the 16 Chap. of the Second Book of the *Deſcription of Inſtruments*: But the Uſe for to *level*, or elſe to *mount* or *Imbaſe* any *piece* of *Ordnance*, is in the 34 Sect. of this Book. To the *ſide* thereof is fitted a *piece* of *Braſs* of the ſame breadth as the *Scale* in thickneſs, with two holes within an *Inch* of each *End*, and two *Screws* fitted to ſerve the four holes, as you may ſee in the *Figure* to the *ſide* of the *Scale*, that if you would *level* or *mount* any *piece* of *Ordnance*, Screw the *plate* to the *end* of the *ſide* B, with both *Screws*, and put the *plate* in the bottom of the *metal* as far as he will go, and put the *tomping* in upon him to keep the *plate* faſt, and then *level* or *mount* your *Piece*, as in 33 Section directed.

But if you will *Imbaſe* any *piece* of *Ordnance* to any *plate* or *point* aſſigned, you muſt *ſcrew* the *plate* to the *end* A, and let the *ſide* with the *Line* of *Numbers* be next the *muzzle*, and ſtop him with the *tomping*, as before; then *Imbaſe* your *Piece*, or put him under the *Line* of *Level* as you will, to what *degree* you pleaſe; and when you have done, *ſcrew* the *plate* to the *ſide* A B, with a *ſcrew* at one *end*, and a *ſcrew* at the other, (there is alſo over the *weight* of the *Shot* a *diviſion* of the *right Ranges*, and likewiſe a *proportion* of *Randoms* of any *piece* of *Ordnance*, upon any *mounture* from *degree* to *degree*; and likewiſe you may put the *diviſion* of *Inches* in the 38 Section, for the *number* of *Inches* and *parts* from 5 *foot* to 14 *foot long*, requireth to *mount* her to any *degree* of *mounture* with great facility and eaſe. There is alſo *Triangle-wiſe* a *plain Scale*, that goes along down by the *degrees* of *diameters*, or *ſteps*, the *Line* is a *Line* of *Chords*, with the *Gnomon-line*, and a *Line* of ſix *hours* of the ſame *Radius*, and a *Line* of *Rhumbs*, with the *Line* of *Sines*; and this is for the making any ſort of *Dial* in any *Laritude* by the following directions, and alſo for the *Plotting* any *Triangle*, or reſolving any Queſtion in *Navigation*, or *Aſtronomy*. You muſt remember, there is a *Braſs Pin* in the *Center* at C for to hang the *Plummet* and *String*, with the *Lope* upon.

Thus I hope I have fitted all ingenious *Gunners* with a *Scale* ſo uſeful, that I will leave it to them to give me commendation for my labour and pains. If I might adviſe *Gunners* of all ſorts, that are able to have one of theſe *Scales* of *Braſs* or *Wood*, to carry about him, to reſolve any Queſtion preſently for his own credit, and it is very portable and fit for his Pocket; but it is beſt to have a caſe of Leather or Cloth to keep it clean; and you may carry a pair of *Compaſſes* with him, and by him you may reſolve moſt of all the Queſtions in this Noble *Art* of *Gunnery*.

On the *ſide* of the *Quadrant* betwixt the *Equinoctial*, and the *Radius*, or *Suns* greateſt *Declination* is a *diviſion* to every 10 *minutes* of the *Suns Amplitude* Riſing and Setting anſwerable to the *Ecliptick Line*, and the *Declination* on the other *ſide* the *Figure*, makes all plain to any *Inſtrument-maker*, without further precept.

SECT. IV.

The Uſe of the Line *of* Numbers *on the* Scale, *for the help of ſuch as cannot* Extract *the* Cube *and* Square-Root.

How by knowing the weight *of one* Bullet, *to find the* weight *of another* Bullet, *the* height *being given.*

A *Bullet* of *Iron* of 6 *Inches height*, weigheth 30 *l.* what will the like *Bullet* of 7 *Inches* in *Diameter* or *height* weigh; always take theſe Rules.

Extend the *Compaſſes* from 6 *Inches* to 7 *Inches Diameter*, the ſame *diſtance* will reach from 30 *l. weight*, turned 3 times over unto 47 *l.* 10 *ounces*, the *weight* of a *Shot* 7 *Inch. high.*

The Arithmetical *way.*

$$\frac{C6C7.\text{Æ}.\ 30\times 343}{216} = 47\ l.\ 10\ \textit{ounc.}\ \tfrac{1}{2}$$

That is *Cube* 6 makes 216, and *Cube* 7 makes 343; then by the *Rule* of *Proportion Multiply* 343 by 30, the *Product* is 10240, *divide* by 216, the *Quotient* is 47 *pound*, $\frac{133}{216}$ or $\frac{61}{108}$, which is 10 *ounces* $\frac{1}{2}$ as before; there is ſomething leſs then 7 *Cube Inches* in one *pound* of *Iron.*

By the Tables *of* Logarithms.

The *Logarithm* of 6 is	07781512
The *Logarithm* of 7 is	08450980
Subſtract the uppermoſt *Number* out of the lower, the *diff.* increaſing.	0669468
	3
The laſt *Number Multiply* by 3, and the triple of this *difference* is	2008404
Added to the *Logarithm* of 30 *l.* with no *ounces*, (which is 3000)	34771212
Gives the *Logarithm* of the weight 47 $\frac{44}{100}$	36779616

Now to know how many *ounces* $\frac{44}{100}$ is, work thus by the *Rule* of *Proportion.*

If 100 gives 64, what will 16 *ounces* give? Anſwer, 10 *ounces* $\frac{24}{100}$; ſo the *Shot* of 7 *Inches diameter* weighs 47 *l.* 10 *ounces* $\frac{24}{100}$ or 47 $\frac{44}{100}$ *pound*, the like way of work is with all ſuch Queſtions.

Sect. V.

Admit the weight *of an* Iron Bullet *being* 30 pound, *the* Diameter *was* 6 Inches, *the* weight *being* 47 $\frac{44}{100}$ *what may the* Diameter *be?*

16:100 10 $\frac{24}{100}$
10
000
100
1000
24
1024
2
480
x024 (64
x66
x

First I will ſhew you how to turn 10 *ounces* and $\frac{24}{100}$ into 100 *parts* of a *pound*; always ſay, If 16 give 100, what ſhall 10 give $\frac{24}{100}$ (64 as you may ſee the work in the Margent, where the *weight* is known, and the *Diameter* required.

Always *Divide* the *weight* 30 *l.* and 47 *l.* $\frac{44}{100}$ into 3 equal *parts*, and that *diſtance* will reach from 6 *Inches Diameter*, to 7 *Inches* the *Diameter* required on the *Line* of *Numbers.*

By the *Tables* the *Logarithm* of 30 is	34771212
The *Logarithm* of 47 $\frac{44}{100}$ *l.* is	36779616
Uppermoſt *Subſtracted* from it, leaves the *difference* increaſing,	2008404
The *difference divided* by 3, or the third part of this *difference.*	0669468
added to 6 *Inch. Diameter*, the *Logarithm*	7781512
Gives the *Logarithm* of 7 *Inch. Diameter* required	08450980

This is the moſt eaſy, ready, and certain way of *Arithmetick*; and ſo work for all ſuch Queſtions, if three *Numbers* be given, to find a fourth in a *Triplicated Proportion.*

Sect. VI.

The Geometrical *finding the* Diameter *for the* weight *of any* Shot *aſſigned.*

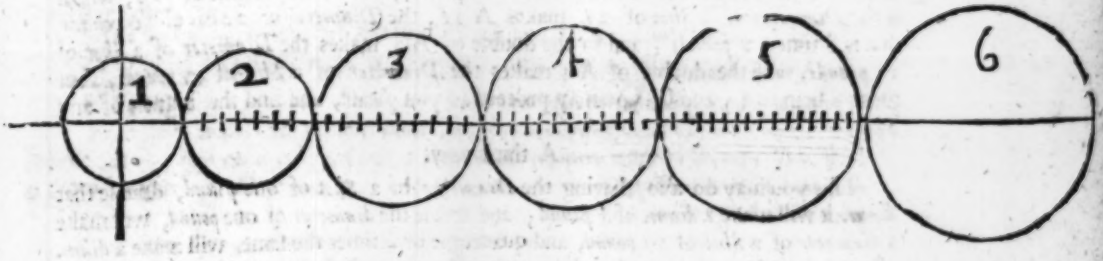
MR. *Gunter* in his firſt Book, Section 4, hath ſhewed the Making of the *Line* of *Solids* on his *Sector*: but this *Rule* ſhews the proportion of the *Diameters* in *weight*: having a *Shot* of one *pound* 2 *pounds* or 3 *pounds* weight of the Metal or *Stone* aſſigned; if it be of a *pound*, *divide* the *Diameter* into 4 equal *parts*, and 5 ſuch *parts* will make a *Diam.* for a *Shot* of the ſaid Metal or *Stone* that ſhall weigh juſt two *l.*

And

And *divide* the *Diameter* of a *Shot* that weighs juſt 2 *l.* into 7 equal *parts*, and 8 ſuch *parts* will make a *Diam.* for a *Shot* of 3 *l.* weight; And *divide* the *Diamet.* of a *Shot* of 3 *l.* weight into 10 equal *parts*, and 11 ſuch *parts* will make a *Shot* for 4 *l.* weight.

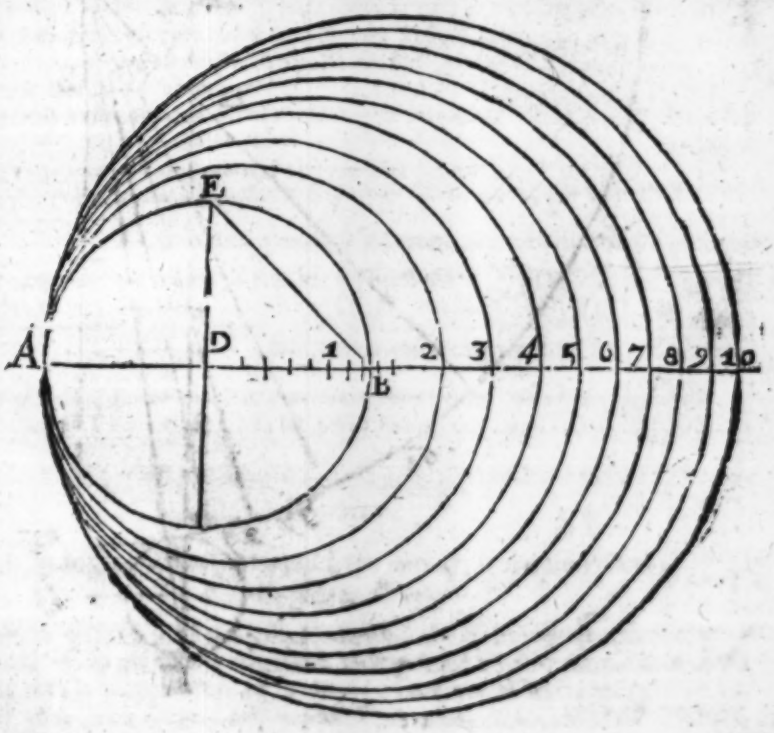
And *divide* the *diam.* for a *Shot* of 4 *l.* weight into 13 *parts*, 14 ſuch *parts* will make a *diam.* of a *Shot* for 5 *l.* weight.

And *divide* the *diam.* of a *Shot* of 5 *l.* weight into 16 equal *parts*, 17 ſuch *parts* will make a *diam.* for a *ſhot* that will weigh 6 *l.* and ſo *dividing* each next *diam.* into 3 equal *parts* more then the next leſſer was Divided into, and it will with one part added from a *diamet.* of a *ſhot* that will weigh juſt 1 *l.* more; and ſo you may proceed infinitely, increaſing or decreaſing, by taking one part leſs, as is appointed to be Divided, for one *l.* leſs, and the next into 8 *l.* leſs, to abate 1 for the Remainder, infinitely decreaſing it.



A ſecond Geometrical *way.*

Firſt you muſt have exactly the *diamet.* of a *ſhot* that weigheth one *pound*, and then deſcribe a *Circle*, whoſe *diamet.* ſhall be juſt equal thereunto; and Divide it into 4 *Qua-*



drants

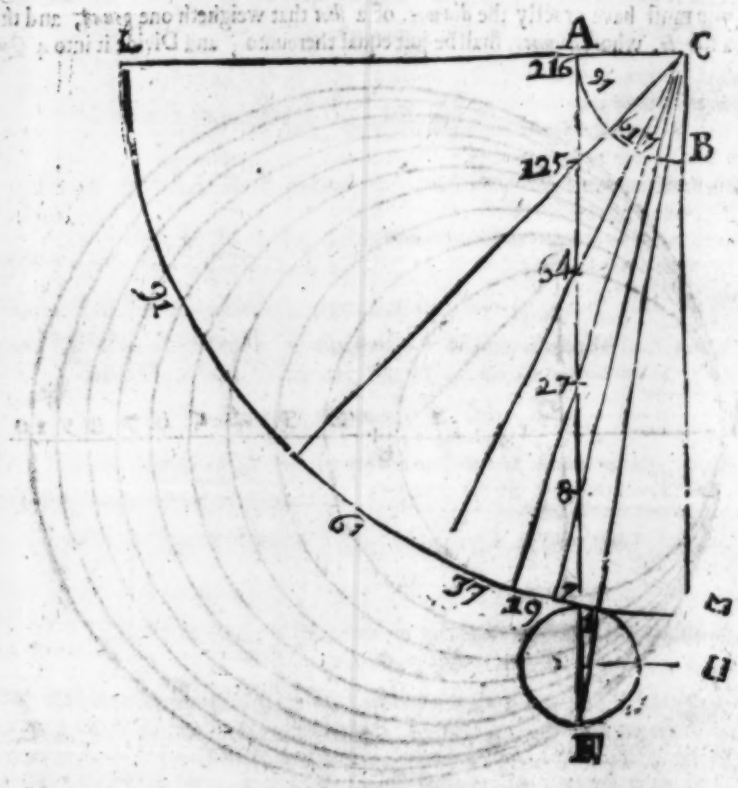
drawn, with 2 *diamet.* cutting each other in the *Centor orthogonally*. Then take the *Chord* of the whole *Quadrant* 90 *degr.* B C in your *Compasses*, and lay it from the *Centor* of the first *Shot* one *pound* D to 2, and so A 2 will be the *Diameter* of a *Shot* of 2 *pound*; Then extend the *Compasses* from 2 to the *Chord* C, and lay that *distance* from D to 3, so will A 3 be the *Diameter* of a *Shot* of 3 *l.* And so likewise extend the *Compasses* from 3 to C, it will reach from D to 4, and from 4 to C, and it reaches from D to 5, and from 5 to C, lay it still always from D to 6; and so continuing till you have proceeded as far as you will: You shall find that if A B were the *Diameter* of one *pound*, A 2 is the *Diameter* of 2 *pound*, and A 3 is the *Diam.* of 3 *l.* and A 4 the *Diam.* of 4 *l.* and A 5 the *Diam.* of 5 *l.* A 6 the *Diam.* of 6 *l.* and lastly, A 8 is the *Diam.* of 8 *l.* and so you may proceed in like manner infinitely.

The *Diameter* of a *Shot* of 1 *pound* is 1 *Inch* $\frac{24}{100}$ *parts.*

Likewise having the *Diameter* of a *Shot* of any weight, the double of the *Diam.* is the *Diam.* of a *Shot* which weighs 8 times as much. Thus the double of A 1, which is A 8, makes the *Diameter* of a *Shot* of 8 *pound*; and so the double of A 2, which is the *Diameter* of a *Shot* of 2 *l.* makes A 16, the *Diameter* of a *Shot* of 16 *pounds*, that is 8 times 2 *pounds*; and so the double of A 3 makes the *Diameter* of a *Shot* of 24 *pounds*, and the double of A 4 makes the *Diameter* of a *Shot* of 32 *pounds*, four times 8 being 32; and so you may proceed as you please, and find the bigness of any *Shot*.

A third way.

This you may do also, having the *Diameter* of a *Shot* of one *pound*, double that *diam.* it will make a *diam.* of 8 *pound*; and treble the *diameter* of one *pound*, will make a *diameter* of a *Shot* of 27 *pound*, and quadruple or 4 times the same, will make a *diam.* of a *Shot* of 64 *pounds*, and 5 *diameters* will make a *Ball* of 125 *l.* and 6 *diameters* of a *Shot* of one *l.* will make a *diameter* of a *Shot* that will weigh 216 *l.*



Now

Now it is convenient to shew how to find the *Mean-divisions* between these extremes; as for the *diameter* of a *Shot* of 2 *l.* 3 *l.* 4 *l.* 5 *l.* 6 *l.* 7 *l.* or what more you will; so as by such progression you may proceed from *pound* to *pound*, until you come to the last term of 216 *pound*; nevertheless the same manner of working will proceed infinitely. Lay the forementioned 6 *diameters* upon one and the same right *Line*; you must at the end of them draw another *Right-line orthogonally*, and set therein the *diamet.* of a such *Shot* given as at C, and from thence draw another *Right-line* parallel to the first, as G H, and then draw a *Quadrat* as A B; and from the *Centre* C draw right *Lines* through all the *divisions* of the *diam.* marked upon the right *Line* A F which are all equal, so shall you have 6 *divisions* to be *divided*; the first being *divided* already, and is the *diam.* of a *Shot* of 1 *l.* but the second *division* is to be in the *Circumference* or *Quadrant* divided into 7 parts equally, because it containeth the second *diameter* unto 8, for adding 1 to 7 it makes 8; the third *division* is into 19 equal parts, which being added to 8, makes 27; the fourth shall be *divided* into 37 equal parts; which together with 27, makes 64; the fifth shall be *divided* into 61 equal parts, which added to 64, makes 125; and lastly, the sixth place must be *divided* into 91 equal parts, unto which *adding* 125, you shall make a *diameter* of a *Shot* of 216 *pound* justly.

Now forasmuch as these *divisions* are difficult to make well, within so small a *Quadrant*: you may therefore describe a greater, as the *Quadrant* L M, and there the *divisions* are more distinct, and larger than in the lesser they can be; Further, you may note, that *Fire-balls*, *Granadoes*, and other *Globous Artifices*, must have the same proportion to their Grandures from their *Ball* of one *pound*, which may be exactly considered; and so by this Method you may make *Balls* of *Lead*, *Brass*, *Stone*, and *Granadoes*, *Fire-balls*, and all other Spherical *Fire-works*, of what weight you will, having one of one *pound* first, to lead you accordingly.

SECT. VII.

To find what proportion is between Bullets *of* Iron, Lead, *and* Stone, *by knowing the* weight *of one* Shot *of* Iron; *to find the* weight *of any other* Shot *of* Lead, Brass, *or* Stone *of the like* Diameter.

THe proportion between *Lead* and *Iron*, is as 2 to 3, so that a *shot* of 2 *pound* of *Iron*, is of like *diameter* or *height* as 3 *l.* of *Lead*.

As for Example.

A *shot* of 6 *Inches diameter* weighs 30 *pound*, to find the *weight* of a *shot* of *Lead* of the same *diameter*.

By the Rule *of* Proportion.

First, if 2 gives 30, what will 3 give? *multiply* and *divide*, and the *Quotient* is 45, the weight of a *shot* of *Lead*.

By the *Tables*, the *Logarithm* of 2 is ——— 03010300
The *Logarithm* of 30 is ——— 14771212
The *Logarithm* of 3 is ——— 04771212
Add the 2 lowermost, the sum is ——— 19542424
Substract the upper *Num.* { *Log.* of 45 *l.* the weight of the *shot* in *Lead* of the same *diam.* } the Remain is the 16532124

2 — 30 — 3
3
90
x
2*x* ⌊45
2*x*

Extend the *Compasses* from 2 to 30, the same *distance* shall reach from 3 to 45; (In like manner work by the rest following.)

The porportion between *Iron* and *Stone*, is as 3 to 8; so that a *shot* of 30 *pound* of *Stone*, is as big as the like *shot* of 80 *l.* of *Iron*; and 11 *l.* $\frac{1}{2}$ of *Stone*, is of the same *diameter* 6 *Inches*, as a *shot* of 30 *l.* of *Iron* and 45 *l.* of *Lead*; the proportion between *Lead* and *Stone*, is as 4 to 1; so that one *shot* of *Lead* of 40 *l.* is of the *height* as a *Stone shot* of 10 *l.*

8 — 30 — 3
3
90
*x*2
3*x* (11$\frac{1}{2}$
88

The proportion between *Lead* and *Brass*, is as 24 to 19,
The proportion between *Iron* and *Brass*, is as 16 to 18.

By

By theſe Rules aforegoing you may Calculate with eaſe, if *Iron ſhot* be wanting, and the other to be had, what *height* and *weight* either *ſhot* of *Lead*, *Braſs*, or *Stone*, ought to be of to fit any *Pieces* of *Ordnance*; and by the ſame Rules here is a *Table* faithfully Calculated, and doth ſhew the weight of any *ſhot* of *Lead*, *Iron*, and *Stone*, from 2 *Inches diam.* to 8 *Inches*, and *Quarters* of *Inches*; the proper *Stone* for this purpoſe is *Marble*, *Pibble*, *Blew hand Stone*; (there may be a little difference of weight in ſome ſort of *Stone*: but theſe do neer agree in weight; you muſt remember in *loading* your *Piece* with a *Shot* of *ſtone*, you muſt not have ſo much *Powder* as you do with *Iron-ſhot*, but abate according to proportion, as is between *Stone* and *Iron*.

Inches.	Quart.	Iron. Poun.	Ounc.	Lead. Poun.	Oun.	Stone. Poun.	Oun.
2		1	1	1	10 1/2	0	7
2	1	1	9	2	6	0	9
2	2	2	2	3	3	0	12
2	3	2	14	4	5	1	1
3		3	12	5	10	1	7
3	1	4	12	7	2	1	13
3	2	6	0	8	15	2	4
3	3	7	5	11	00	2	12
4		8	15	13	07	3	6
4	1	10	10 1/2	16	0	4	0
4	2	12	10 1/2	18	15	4	12
4	3	14	14	22	5	5	9
5		17	05	26	2	6	8
5	1	20	1	30	2	7	8
5	2	23	2	34	11	8	11
5	3	26	6	39	9	9	14
6		30	00	45	00	11	04
6	1	34	00	51	00	12	12
6	2	38	00	57	00	14	04
6	3	42	00	62	00	15	12
7		48	00	72	00	18	00
7	1	53	00	79	08	20	00
7	2	58	00	87	00	22	12
7	3	64	00	96	00	24	00
8		71		106	8	26	10

The uſe of the Table, *to find the* weight *of any* Shot *of* Iron, Lead, *or* Stone *from* 2 *to* 8 Inches Diameter.

This *Table* is exactly Calculated, and the uſe thereof is very eaſy; we will make it plain by two *Examples*; I would know of *Shot* of 6 *Inches*, their *weight* in *Iron*, *Lead*, and *Stone*: the firſt Column is *Inches*, the ſecond *Quarters* of *Inch.* the third *Poun.* and *Ounc.* of *Iron*, fourth *Pounds* and *Ounces* of *Lead*, fifth *Poun.* and *Ounces* of *Stone*.

Enter the *Table* with 6 *Inches diam.* in the firſt Column, and in that *Line* you ſhall have 30 *poun.* of *Iron*, 45 *pound* of *Lead*, 11 *pound* 4 *ounces* of *Stone*, the *weight* of 6 *Inches diam.* And likewiſe, for 4 *Inches* 1/4 *diam.* the *weight* of an *Iron Shot* is 14 *pound*, 14 *ounc.* of *Lead* 22 *pound* 5 *ounces*, of *Stone* 5 *pound* 9 *ounces*; and ſo of the reſt.

Sect. VIII.

How by knowing the weight *of one* Piece *of* Ordnance, *to find the* weight *of another* Piece *being of that very ſhape of the ſame* Metal, *or any other* Metal.

FIrſt, with a pair of *Crallapers* take the greateſt thickneſs of your *Piece*, as at the *Baſe-Ring*; and alſo the *Piece*, whoſe weight you know not.

Example.

Admit a *Braſs Saker* of 1900 weight, hath his greateſt thickneſs 11 1/2 *Inches*; Now I find the *diam.* of the other *Braſs Piece*, whoſe weight I know not, to be 8 1/4: then always by theſe Rules:

If

If the greateſt *diam.* and weight is given, to find leſs weight, or elſe the contrary.

As the *Logarithm* greateſt *diameter*, 11 $\frac{10}{100}$ —— 306069
The *Logarithm* of the leaſt, 8 $\frac{71}{100}$ —— 294200
The Difference increaſing. —— 11869
3
× 3 or the Triple of this Difference *Subſtract* —— 35607
From the *Logarithm* of the weight given 1900 —— 327835
Reſt the *Logarithm* of 837, the weight required, —— 292228

Or extend the *Compaſſes* from 11 $\frac{1}{2}$ to 8 $\frac{71}{100}$ *Inches diam.* the ſame diſtance will reach from the weight given 1900 *pound* turned 3 times over to 837 *pound.*

The *Arithmetical* way.

$$\frac{C\ 8\frac{1}{4} \times 1900}{C\ 11\frac{1}{2}} = 837\ l.$$ weight almoſt in *Braſs.*

But if the *Piece* had been *Iron* whoſe weight you ſought, you muſt always do as before with the *Braſs*, and find the difference of their Metals by the laſt Problem, which is 16 to 18, then ſay by the Tables,

As the *Logarithm* of *Braſs*, 18, —— 125527
is to the *Logarithm* of weight in *Braſs* 835 —— 292272
So is the *Logarithm* of proportion of *Iron* 16 —— 120412
The Sum 412684
to the *Logarithm* of the weight in *Iron* 744 —— 287157

Or extend the *Compaſſes* from 18 to 837, the ſame diſtance will reach from 16 to 744 *l.* weight in *Iron.*

Arithmetical way.

$$\frac{X\ 837 \text{ by } 16}{18} = 744\ l.$$ of *Iron* almoſt.

SECT. IX.

How to make a Shot *of* Lead *and* Stone, *the* Stone *being put in the Mould in which the* Leaden Shot *ſhould afterwards be caſt, to be of the like* Diameter *and* Weight *as an* Iron Shot *is of.*

It is found by experience, that if you take 5 parts *Lead*, and one part *Stone*, it will come very near the matter, wanting not above 3 Ounces, which is nothing, reſpecting the difference you ſhall find in *Pibble Stones.* Here you have a Table how much *Lead*, and how much *Stone* muſt be together, to make the equal of *Iron Shot*, from 1 *Inch*, and to every half in the firſt and ſecond Column to 8 *Inch. Diameter*; the third Column is how much *Lead*, the fourth how much *Stone*, the fifth how much weight both together.

Inches.	Quart.	Lead. Poun.	Lead. Oun.	Stone. Poun.	Stone. Oun.	Both together. Poun.	Both together. Oun.
1		0	1 $\frac{3}{4}$	0	0 $\frac{1}{4}$	0	2
1	2	0	6 $\frac{1}{4}$	0	1 $\frac{3}{4}$	0	8
2		0	14	0	4	1	2
2	2	0	12	0	8	2	4
3		3	2	0	10	3	12
3	2	5	0	1	0	5	0
4		7	7	1	8	8	15
4	2	10	8	2	2	12	10
5		14	7	2	14	17	5
5	2	19	4	3	12	23	0
6		25	0	5	0	30	0
6	2	32	0	6	0	38	0
7		40	0	8	0	48	0
7	2	48	0	10	0	58	0
8		59	0	12	0	71	0

Sect. X.

How by knowing what quantity of Powder *will load one* Piece *of* Ordnance; *to know how much will load any other* Piece *whatsoever.*

ADmit you have a *Saker* of three *Inches* three quarters at the *bore diam.* and it requires 4 *pound* of *Powder*; what will a *Demi-Canon* of 6 $\frac{1}{3}$ *Inch.* require? Work by these Rules always.

As the *Logarithm* of 3 $\frac{71}{100}$ *diam.* —— 257403
The *Logarithm* of 6 $\frac{10}{100}$ *Inch. diam.* —— 281291
the difference increasing, —— 23888
—— (3
The triple of the difference added —— 71664
The *Logarithm* of 4 *l.* of *Powder*, 0 *ounces.* —— 160206
to the *Logarithm* of 20 $\frac{8}{10}$ or 20 $\frac{84}{100}$ *l.* of *Pow.* 231870

100--84-16
16
504
84
1344

So that the *Demi-Canon* must have 20 *pound* 13 *ounces* for her Charge of *Powder*; reduce the *Fraction* as before in the Margin into *ounces.*

By the *Scale*, extend the *Compasses* from 3 $\frac{71}{100}$ to 6 $\frac{10}{100}$ *Inches diam.* the same distance turned three times over from 4, will reach to 20 $\frac{84}{100}$ *pound* weight, as before.

The *Arithmetical* way.

3 44 | 13 $\frac{44}{100}$
100

$\frac{C\ 6\ \frac{10}{100} \times 4}{3\ \frac{71}{100}\ C}$ ==== 20 *l.* 13 *ounces* of *Powder* for to load a *Demi-Canon.*

You are likewise to understand that the *Demi-Canon* should be fortified so well as the *Saker* by this Rule.

The *diameter* of the *Saker* is 3 $\frac{71}{100}$ *Inches* —— 257403
The *Demi-Canon diam.* is 6 $\frac{10}{100}$ *Inches* —— 281291
the difference increasing, —— 23888
—— (3
The triple of the difference by (3) —— 71664
added to the *Logar.* of 1600 weight of *Saker* —— 320412
gives the *Logar.* of 8332 the *demi-Canon*, —— 392076

Also by the *Scale*, and *Arithmetick* Rules, as in the foregoing Rules you will find the weight of the *Demi-Canon* 8332 *pound*, proportionable according to the *Saker*; but suppose the *Demi-Canon* to be no more than 6000 weight, then you must use these Rules.

The supposed weight of the *Demi-canon* 6000 —— 377815
add the weight of the *Powder* well fortified, is 20 $\frac{84}{100}$ —— 331889
The sum is —— 709704
Substract the weight of the *Gun* well fortified 8332 —— 392074
leaves the weight of the *Powder* 15 *pound*, —— 317630

Fifteen *pound* being a sufficient Charge for that *Piece*: or extend the *Compasses* from 6000 to 8332, the same distance will reach from 20 $\frac{84}{100}$ to 15 *l.* of *Powder*, as before.

The *Arithmetical* way.

$\frac{6000 \times 20\ pound\ 13\ ounces.}{8332}$ ==== 15 *pound* almost, as before.

Thus

Thus you are always to take care of over-loading your *Piece*, which error many run into, when they call a *Piece* a *Demi-canon*, they presently load her with so much as is allowed for such a *Piece* so named, seldom examining whether the *Piece* have Metal enough for such a Charge; by which mistake they endanger their own lives, and others which stand near. Now, for easy plain Rules, I say you never had before laid down in this manner, to resolve these things; for if you compare these Rules with *Nath. Nye*, Master Gunner of the City of *Worcester*, or any other *Art* of *Gunnery*, you will find a great deal of difficulty in *Cubing* and *Extracting* the *Cube Root*, and with reducing and Fractions (which here you may do five Questions, for one that way, and more true and near, therefore I compare them to his Rules.

How to make the true dispert of any true bored Piece *of* Ordnance.

Now we have found how to proportion *Shot* and *Powder* to any *Piece* of *Ordnance* true bored; before we Load and Fire, let us find the true Dispert to direct the *Shot* to the assigned mark.

By the same Rules you may find the *Diameter* of a *Shot* with a *String*.

Girt the *Piece* about the *Base Ring* round at the Britch with a Thred, and also the *Muzzle Ring* at the Mouth, and divide them two measures into 22 equal parts, which you may presently do, by applying it to a *Scale*, that hath an *inch* divided into 10 parts, and Divide the parts by 7, and Substract the greater out of the lesser, and take half the difference, is the true Dispert.

As for Example.

Suppose when I have measured the length of each String, and Divided it into 22 equal parts, I find that 7 parts of the longer String is 11 *inches*, and 7 parts of the shorter is 9 *inches*; I Substract 9 out of 11, and the remain is 2, the half is 1, which is the true Dispert.

Another way to Dispert any Piece.

If you have a pair of *Callipers*, as in the general Figure A C B, as you take the *diameter* of a *Shot*, and apply it to a *Scale* Divided into 8 or 10 parts, to know the Contents thereof; so with the *Callipers* take the greatest thickness or *diam.* of the *Base Ring*, and by your *Scale* see how much that is; as admit that the length of the Line *a*: *b*: *c*: *d*, where the *diam.* of the *Base Ring*, then take the *diam.* of the *Muzzle Ring*; as admit it be *a*, *b*, as you may try by the Figure of the *Gun* in the general Figure; then Divide the difference *b d* into 2 equal parts, and one of them is the Dispert, put it upon the Muzzle of the *Gun* as C B, and stick it fast on the top of the *Muzzle Ring* with a little Pitch or Wax, and from the *Base Ring* at A in the Figure to the top of the Dispert at B, take aim to the Mark you would shoot to, and that is the way to hit; but if *Callipers* be wanting, take a Stick that is straight and flat, and 2 Strings with two *Musket Bullets* at the end, and two Loops made at the other end, the Stick being something more than the *diam.* at the *Base Ring*, and put the Stick upon the top of the *Ring* at the *Muzzle*, as you see the Fig. H K on the *Gun*, and put the Strings so nearer and farther, until they only touch the side of the matter of the *Muzzle Ring*, and mark the Loops on the Stick, and put the Stick on the *Base Ring*, and do in like manner, and mark the Sticks; and the Work will be the same, as it were taken by the *Callipers*; and the difference of the two Notches on the Stick will be *a b* the *Base Ring*, and *a b* the Notches of the *diam.* of the *Muzzle Ring*, and half the difference *b c* or *c d* is the Dispert, as before, if the *Piece* be true bored.

A fourth way to Dispert a Piece *of* Ordnance.

If the *Piece* be not Chamber-bored, take the *Priming Iron*, and put it down in the Touch-hole, until it rest upon the Metal in the bottom of the bore, there make a mark with the *Base Ring*; likewise apply the *Priming Iron* to the bottom of the Metal at the mouth, and so much higher as the mark is which you made at the *Base Ring*, than the *Muzzle Ring*, the difference is the true Dispert.

Sect. XI.

How to know whether your Piece *be* Chamber-bored.

FIrſt you may Diſpert your *Piece* the three firſt ways, and when they agree in one, take that for the true Diſpert; then with your *Priming Iron* take the Diſpert this laſt way; which done, compare it with the other Diſpert firſt found, and what it wants, is the juſt difference of the *Chamber* from the Bore of the *Piece*.

Admit the Diſpert truly found by the two firſt ways be three *Inches*, as by this laſt way is but two *Inches*, it ſhews that the *Chamber* differs from the true Bore on each ſide one *Inch*; ſo that if the Bore of the *Piece* be five *Inches* high, the *Chamber* being one *Inch* on each ſide lower, is but three *Inches* high: the like Obſervation we would always have you to make, that you may not afterwards be deceived in making *Cartredges* of Canvas or Paper to load the ſame.

Sect. XII.

How to know what Diameter *every* Shot *muſt be of to fit any* Piece *of* Ordnance, *or to chooſe* Shot *for* Ordnance.

TAke the *Diameter* of the Bore of the *Piece*, and Divide into 20 equal parts, and one of thoſe parts is ſufficient vent for any *Piece*, the reſt of the 19 parts muſt be the height of the *Shot*; but now adays moſt *Gunners* allow the *Shot* to be juſt one quarter of an *Inch* lower than the Bore; which Rule makes the *Shot* too big for a *Canon*, and too little for a *Faulcon*; but if the mouth of the *Piece* be grown wider, then the reſt of the *Cylinder* within by often ſhooting; to fit *Shot* to ſuch a *Piece*, you muſt trie with ſeveral *Rammers-heads*, until you find the *Diameter* of the Bore in that place where the *Shot* uſeth to lie in the *Piece*; and a *Shot* of one twentieth part lower than that *Piece* is ſufficient; therefore let *Gunners* remember to trie the *Piece*, as directed.

Sect. XIII.

How to find what Flaws, Cracks, *and* Honey-combs *are in* Pieces *of* Ordnance.

THere is one good way, as ſoon as you have diſcharged a *Piece* of *Ordnance*, cover the mouth of the *Piece* cloſe, and ſtop the *Touch-hole* at the inſtant time; if there be any unknown *Cracks* or *Flaws* which go through the Metal, a viſible Smoak will come through thoſe *Cracks* and *Flaws*; if not, the *Gun* is not *cracked*.

There is a way to reflect the Sun-beams when he ſhineth, with a Looking-glaſs or Steel in at the hallow *Cylinder* of the *Piece*; for by this means a bright and clear light will be within, and by that light you will ſee every *Flaw*, *Crack*, or *Honey-comb*.

But this way you may ſee at any time; take a Stick ſomething longer than the *Piece*, cleave the end of the ſaid Stick, for to hold an end of a Candle, light the Candle, and put it into the cleft end of the Stick, and put it into the *Piece*; by this light obſerve by degrees whether from the one end to the other there be any of the foreſaid *Flaws*, *Cracks* or *Honey-combs* in the *Piece*.

This is a uſual way likewiſe, if in ſtriking a *Piece* upon ſeveral places of the Metal with a Hammer of Iron, you ſhall at any ſtroak hear a hoarſe ſound, then without doubt there is *Honey-combs*: but if in ſo ſtriking the *Piece*, you ſhall at every ſtroak hear a clear ſound, then may you be ſure your *Piece* is clear of any *Honey-combs*, *Cracks*, or *Flaws*.

SECT. XIV.

How to find whether a Piece *of* Ordnance *be true bored, or not.*

FIrſt, there muſt be provided a Staff, and two Rammer heads upon the Staff, and on the Rammers heads there muſt be two right Lines drawn upon them; that is, Divide the two Rammer heads that are the juſt height, and fit the bore into two equal parts oppoſite to each other, and draw Lines thereon; the like do by the Staff, that the Lines on the Rammer heads may ſtand alike, one at one end, and at the other end, as you ſee in the general Figure L M.

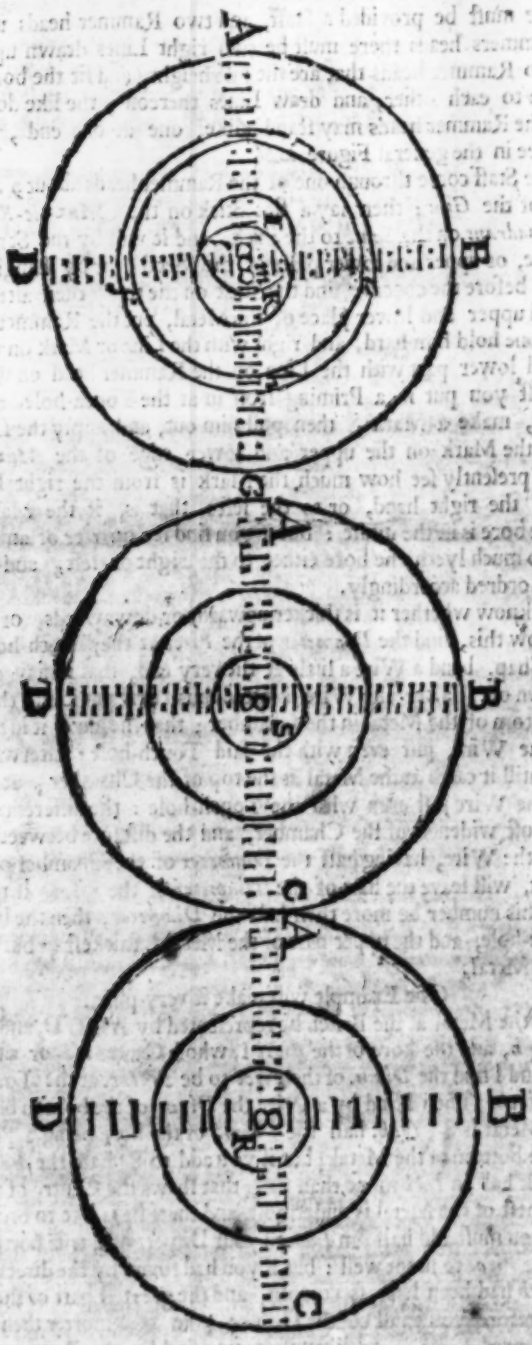
And let the Staff come through one of the Rammer heads about 9 *Inches* longer than the *Cylinder* of the *Gun*; then lay a flat Stick on the *Muzzle-Ring*, and hold the ſide of the *Quadrant* on the *Scale* to the Stick, and it will by the String and Plummet find the middle, or upper and lower place of the Metal; or by hanging a Plumb-Line and *Quadrant* before the concave, and the Stick on the top; then after you have found the Point, and upper and lower place of the Metal, put the Rammer head L into the *Gun*, and let one hold him hard, and right with the Line or Mark on the upper part of the *Gun*, and lower part with the Line on the Rammer head on the Staff above and below, whilſt you put in a Priming Iron in at the Touch-hole, and ſtrike hard the Rammer head, make a Mark; then pull him out, and apply the Line on the Rammer head to the Mark on the upper and lower edge of the *Muzzle* of the *Gun*, and you may preſently ſee how much the Mark is from the right Line of the Rammer head, to the right hand, or to the left; that is, if the Mark is juſt on the right Line, the bore is in the midſt: but if you find it a quarter of an *Inch* on the right or left hand, ſo much lyeth the bore either to the right or left; and in Shooting, the *Piece* muſt be ordred accordingly.

But now to know whether it is thicker upwards or downwards, or how the bore is; the way to know this, find the *Diameter* of the *Piece* at the Touch-hole, as is already taught in 10 Chap. bend a Wire a little at the very end, that it may catch at the Metal when it is drawn out; after the Wire is fitted thus, firſt put it into the Touch-hole till it touch the bottom of the Metal in the Chamber; then holding it in that place, make a mark upon the Wire, juſt even with the ſaid Touch-hole; afterwards draw up the ſame Wire, untill it catch at the Metal at the top of the Chamber; at that inſtant make a mark upon the Wire juſt even with the Touch-hole: the difference betwixt the two marks, is the juſt wideneſs of the Chamber, and the diſtance between the firſt mark, and the end of the Wire, having half the *Diameter* of the Chamber of the *Piece* Subſtracted from it, will leave the half of the *Diameter* of the *Piece*, if the *Piece* be true bored; but if this number be more then half the *Diameter*, then the bore lyeth too far from the Touch-hole, and the upper part of the Metal is thickeſt; but if leſs, the under part hath moſt Metal.

One Example will make it very plain.

Suppoſe that the Metal at the Britch be repreſented by A B C D, and the Metal at the Muzzle by *e f g h*, and the bore of the *Piece* I, whoſe Centre is *l*, or the bore K, whoſe Centre is *m*: (and I find the *Diam.* of the *Piece* to be 21 *Inc.* at the Touch-hole, the half thereof is 10 ½ *inch.* Then I find by a Wire the *Diam.* of the bore to be 5 *Inch.* but the bottom of the Metal is 8 ½ *Inch.* half the *Diam.* of the bore being 2 ½ *Inches* to a 10 ½ makes 13 to the bottom of the Metal; but if you add to 8 ½ half the *diam.* of the bore 2 ½ it is 11, which is half an *Inch* more than 10 ½, that ſhews the Centre of the bore to be at R, and the thinneſt of the Metal is undermoſt, and there he is like to break firſt; beſides, it ſhews that you muſt add half an *Inch* to your Diſpert of a true bored *Piece*, to make a Diſpert for the *Piece* to ſhoot well: but if you had found by the direction before given, that the ½ an *Inch* had been leſs, as 10 only, and the greateſt part of the Metal had been under; and therefore you muſt cut the Diſpert ½ an *Inch* ſhorter then a Diſpert made for ſuch a true bored *Piece*; and likewiſe if you find by the Rammer head, and prick with a Wire at the Touch-hole ½ an *Inch* difference to the right or left hand, as *l* or *m*, that ſide which is the thinneſt, you muſt put the Diſpert cut ½ an *Inch* ſhorter, the three Figures makes all plain as it is written, as you may ſee by the direction of *inches*.

SECT. XV.


A
B
C
D
A
B
C
D
A
B
C
D

SECT. XV.

Of Iron Ordnance *what quantity of* Powder *to allow for their Loading.*

YOu muſt firſt Calculate a Charge of *Powder* for the ſaid *Iron Piece*, as if it had been a *Braſs Piece*, and in caſe you want the weight of the ſaid *Iron Piece*, you muſt find it as you were taught in Chap. 7, and when you have found it as is taught in Chap. 9, how much *Powder* will Load the ſame if it were of *Braſs*, then juſt 3 quarters ſo much is ſufficient to Load an *Iron Piece*.

As for Example.

A Braſs *Saker* of 1500 weight requires 4 *l.* what will an Iron *Demi-Culvering* of 2800 weight require? Work as in the 9 Chap. and you ſhall find 6 *l.* $\frac{6}{15}$ or 6 *l.* 14 $\frac{1}{2}$ *ounces*, ſo well fortified as the *Saker*, will ſerve a Braſs *Demi-Culvering* for a Charge. The which we will likewiſe examine by the Rule in the 7 Chapter.

The Braſs *Saker's diam.* is 3 $\frac{11}{115}$ *inch. Logarithm* ——	257403
The *diam.* of the *Demi-Culvering* Braſs 4 $\frac{10}{115}$ *inches* ——	265321
The difference increaſing. ——	7918 (3
The triple of the difference. ——	23754
The weight of the *Saker* added to it 1500 ——	317609
gives the *Logar.* of the weight of of the *Demi-C.* Braſs 2592 *l.*	341363

Or by the *Scale*, extend the *Compaſſes* from 3 $\frac{71}{100}$ to 4 $\frac{10}{100}$ the ſame diſtance turned 3 times from 1500, will reach 2592 *l.* as before.

The *Arithmetical way.*

$\frac{4\frac{10}{100}C \times 1500}{3\frac{1}{4}C}$ ==== is equal to the weight 2592 *pound*, which is the weight ſuch a *Demi-Culvering* ſhould be of that burneth 6 *l.* 14 $\frac{1}{2}$ *ounces* of *Powder*.

To find what a *Demiculvering* of Braſs of 28 hundred will require, Work thus.

The *Logarithm* of 2592 ——	341363
The *Logarithm* of 2800 ——	344715
The difference increaſing. ——	3352
The one third of the difference, ——	1117
The weight in *Powder* 6 $\frac{10}{115}$ *l.* added ——	283884
gives the weight 7 *l.* 8 *ounces* ——	285001

Or extend the *Compaſſes* from 2592 to 2800, the ſame diſtance will reach from 6 $\frac{10}{15}$ to 7 $\frac{1}{2}$ *l.* as before.

The *Arithmetical* way.

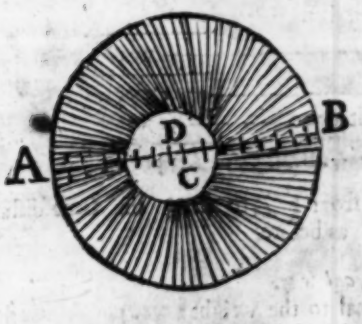
$\frac{2800 \times 6\frac{10}{15}}{2592}$ ==== 7 *pound* 8 *ounces*, as before.

Of which number you muſt take 3 Quarters for a Charge for the ſaid *Demi-Culvering*, $\frac{1}{4}$ thereof, being 5 *pound* 10 *ounces*, will be a ſufficient Charge for ſuch a *Piece*; and alſo whatſoever you find on the *Scale*, and in the *Table* in the third Chapter for Braſs *Pieces*, take three quarters thereof for the Charge of your Iron *Piece*, if they be near that weight.

Sect. XVI.

To know what quantity of Powder *ſhould be allowed to a* Piece *of* Ordnance *not truly bored.*

ADmit the *diameter* of the Metal of the *Piece* at the Touch-hole be 16 *inches*, and the *diameter* at the bore is 5 $\frac{3}{4}$ *inches*, the weight of the *Piece* 4850, as you may ſee by Chap. 7, ſuch a *Piece* you may find in the ninth Chap. requires 11 *l.* for her due Charge, being near two *Diameters* of her bore in *Powder*; But by my *Inſtrument* in the general Figure, with the two Rammers heads at the two ends L M (at the Rammer end L that was in the *Gun* at the Touch-hole, I find by the prick at S on the Rammer, the ſoule or bore to be 1 *inch* out of his place, or 1 *inch* from the middle of the Metal; then I conclude, that the thinneſt part of the Metal is 4 *inches* $\frac{1}{3}$ parts, and the thickeſt ſide 6 and $\frac{1}{3}$ parts; by which it appears, that one ſide is juſt 2 *inches* thicker than the other ſide, as you may ſee plainly by this Figure; the Line A B divided is the *diameter* or greateſt thickneſs at the Touch-hole, every Diviſion ſignifies an *inch* from the inward Circle to the outward Circle, is the thickneſs of the Metal; the inward Circle ſignifies the bore of the *Piece*, which you may ſee is juſt an *inch* from the true bore or Centre of the outmoſt Circle; therefore you muſt work as if the *Piece* were fortified no more than only ſo much as the thinneſt part of the Metal is, which here doth appear to be 4 *inches* $\frac{1}{4}$ parts, the $\frac{1}{3}$ of the *diameter* of the bore is 2 $\frac{1}{3}$ *inches* added, makes 7 from A to D, the Centre of the bore being the thinneſt part of the Metal, the whole *diameter* being 14, which is the true *diameter*, by reaſon the thinneſt ſide of the Metal is but 4 $\frac{1}{3}$ *inches* thick.



thinneſt 4:3
$\frac{1}{3}$ *Diam.* 2:5
Centre 6:8
thinneſt 4:3
of Met. 4:3
5:2
Dem. 14:0

And by this you muſt proportion your Charge by the former being 16 *inches*, if the bore had been placed at C in the true Centre, then evermore by theſe Rules.

10:4:16
4
9(4|6
2|0

The *Logarithm* of greateſt *diameter* 16 is —— 220412
The *Logarithm* of the leſs *diameter* 14:0 *l.* —— 214612
The difference decreaſing, —— 5800
—— 3
The triple of the difference Subſtracted —— 17400,
from the *Logarithm* of 11 *l. Powder* 0 *ounces*, —— 204139
Leaves the *Logarithm* of the *Powder* 7 $\frac{4}{16}$ *pound* —— 186739

So that 7 *pound* $\frac{4}{16}$ or 6 *ounces*, is a ſufficient Charge for ſuch a falſe bored *Piece*; or extend the *Compaſſes* from 16 to 14, the ſame diſtance 3 times repeated from 11, will reach 7 $\frac{4}{16}$ *pound*, as before.

The *Arithmetical* way.

C 14 is ⌋2744 × 11
——————— ==== 7 *pound* 6 *ounces*, as before.
C 16 is ⌋4096

Sect. XVII.

SECT. XVII.

How Moulds, Forms, *and* Cartredges, *are to be made for any ſort of* Ordnance.

CArtredges are uſually made of Canvas and Paper-Royal; firſt take the height of the bore of the *Piece* of your *Scale* a little leſs $\frac{1}{30}$ part of an *inch* of the *diameter* for the Vent, and three *diam.* of the Chamber of the *Piece* in breadth, cut the Paper and the Canvas, and for the *Canon* in height to the whole *Culvering*, is allowed about 2 *diam.* of the *Piece*, from the *Culvering* to the *Minion*, the Charge the length of two *diamet.* and $\frac{1}{2}$ all from the *Minion* to the *Baſe* 3 *diameters* of *Powder*, and make them at firſt about 4 *diameters* long, and according to the directions here given, mark them, or put a *pound* of *Powder* into each *Cartredge*, and meaſure how full it fils by your *Scale* for each *Gun* in your *Ship*, or *Army*; and by that Rule you may know how to make a Table, to make a Scale, to mark the Cartredge for the full loading, or diminiſhing of your *Powder*, according to the goodneſs or badneſs of the *Powder*; and to the extraordinary over-heating of the *Piece*, having reſolved for what ſort of *Ordnance* are to ſerve you, and accordingly to have a form of Wood turned to the height of the Cartredge, which is the 21 part of 22, the *diameter* of the bore, and $\frac{1}{2}$ an *inch* longer than the Cartredge is to be, before you paſte your Paper on the form, firſt Tallow him, ſo will the Canvas and Paper ſlip off without ſtarting or tearing; if you will make for tapered bore *Guns*, your Forms muſt be accordingly tapered, if you make Cartredges of Canvas, allow one *inch* for the Seams; but of Paper $\frac{1}{4}$ of an *inch* more than 3 *diameters* for the paſting. If once about the former, having a bottom fitted upon the end of the former, and Cartredge; you muſt paſte the bottom cloſe, and hard round about, then let them be well dryed, and then mark every one with Black or Red Lead, or Ink, how high they ought to be filled; which if you have no Ladles, Scales, nor Weights, theſe *diameters* of the Bullets make a reaſonable Charge for the *Canon* 2 $\frac{1}{2}$ for a *Culvering* 3, and for the *Saker* 3 $\frac{1}{2}$ for the leſſer *Pieces* 3 $\frac{1}{2}$ of the *diameter* of the Bullet, and let ſome want of their weight againſt time they are over hot, or elſe you may endanger your ſelf, and others.

SECT. XVIII.

How to make Ladles, Rammers; *or* Spunges *for all ſorts of* Ordnance.

EVery Mr. *Gunner* doth, or ſhould know how to Trace, Cut out, and alſo make up and finiſh all Ladles, Spunges, and Rammers, and direct others how to make, and finiſh the ſame ready for uſe.

You have in the Table in the third Chapter the length and breadth of the Ladle, anſwerable to each *Gun* in *inches* and parts, and you muſt allow $\frac{1}{7}$ a *diameter* more to incloſe the head of the Staff within the Plate; the Button, or head of the Ladle-ſtaff muſt be the height of the *Shot* almoſt; for Spunges, their bottoms and heads are to be made of ſoft Wood, as Aſp, Birch, Willow, to be one *diameter* $\frac{1}{4}$ in length, and $\frac{1}{2}$, or a very little leſs of the height of the *Shot*, and covered with Sheep-skins, Wool, and nailed with Cooper's Nails, that together they may fill the concave of the *Piece*.

Let the Bottom or Head of the Rammers be of good hard Wood, and the height, as before one, and the length $\frac{1}{7}$ of the *diameter* of the *Shot* at one end next the Staff, it muſt be ſo turned, that a Ferril of Braſs may be put thereon to ſave the Head from cleaving, when you Ramme home the *Shot*, the Buttons muſt be bored $\frac{1}{7}$ for the Staff to be put in and faſtned with a Pin through, and his length a Foot more than the concave of the *Gun*.

To make a Ladle for a Chamber-bored *Piece*, your *Compaſſes* opened to juſt the *diam.* of your *Chamber* within $\frac{1}{2}$ part of an *inch*, Divide the meaſure into two equal parts, then let your *Compaſſes* to one of them, and by that diſtance draw a Circle on a Slat or Paper, the *diam.* of that Circle is $\frac{1}{6}$ ſhorter than the *diam.* of the *Chamber*, and take $\frac{1}{3}$ parts of the Circle for the breadth of the Plate of the Ladle; and for *Cannons*, the length ought to be twice and $\frac{1}{3}$ parts to hold at two times, the juſt quantity of *Powder*.

Sect. XIX.

How the Carriage *of a* Piece *ſhould be made.*

MEaſure the length of the *Cylinder* of the bore, and once, and half that length ſhould be the length of the *Carriage*, and in depth 4 *diameters* of the bore of the *Piece* at the fore-end, in the middle 3 and $\frac{1}{2}$, and at the end next the ground 2 and $\frac{1}{2}$, the thickneſs the *diameter* of the *Shot*; the Wheels ſhould be one half the length of the *Piece* in height; the *Saker* and *Minion* muſt exceed the former by $\frac{1}{11}$ part, the *Faulcon* and *Faulconet* by one ſixth part. *Sea-Carriages* are made leſs, as the Block-maker that makes them hath Rules for.

Sect. XX.

To know whether the Trunnions *of any* Piece *of* Ordnance *are placed right.*

MEaſure the length of the *Cylinder* of the bore from the Muzzle to the Britch, Divide the length by 7, and Multiply the Quotient by 3, and the Product will ſhew you how many *Inches* the *Trunnions* muſt ſtand from the loweſt part of the concavity of the *Piece*, and you muſt know that the *Trunnions* ought to be placed, ſo that $\frac{2}{3}$ of the *Piece* may be ſeen above, or in that place where the *Trunnions* are ſet.

Sect. XXI.

How much Rope *will make* Britchings *and* Tackles *for any* Piece.

IN *Ships* that carry *Guns*, the moſt experienced *Gunners* take this Rule. Look how many *foot* your *Piece* is in length, four times ſo much is the length of the *Tackle*, and their *Britchings* twice the length; and if the *Ropes* be ſuſpected not to be good, they nail down *Quoyners* to the Fore-Trucks of heavy *Guns*, that he may not have any play; and if *Britchings*, and *Tackles*, and *Quoyners* ſhould give way in foul weather, preſently diſmount her, that is the ſureſt way. The *Rammers* and *Spunges* are made of four *Strand-Ropes* beſt, and ſerved cloſe, and ſewed with Yarn, that they may be ſtiff to Ramme home the *Shot* and *Wadd*.

Sect. XXII.

What Powder *is allowed for Proof, and what for Action of each* Piece.

FOr the biggeſt ſort of *Pieces* and *Cannons*; for Proof $\frac{1}{4}$, and for Service $\frac{1}{3}$ her weight of her *Iron Shot*, for the *Culvering* the weight of the *Shot* almoſt for Proof, and for Action $\frac{1}{3}$, for the *Saker* and *Faulcon* $\frac{1}{2}$, and for leſſer *Pieces* the whole weight of the *Shot*, until they grow hot; and for Proof, the leſſer *Pieces* give them 1 and $\frac{1}{4}$ of the weight of the Bullet in Powder.

Sect. XXIII.

The difference between the Common Legitimate Pieces, *and the Baſtard* Pieces, *and Extraordinary* Pieces.

Gunners call them Legitimate *Pieces*, as have due length of their Chaſe according to the height of their bores; Baſtard *Pieces* are ſuch as have ſhorter Chaſes, than the Proportion of their bore doth require; and Extraordinary, are ſuch *Pieces* as have longer Chaſes, than the proportion of their bore alloweth; and theſe are called Baſtard *Cannons*, *Culverings*; and ſo likewiſe of *Saker* and *Faulcon*, which by your *Scale*, and the Rule thereon, you may preſently find them.

Sect. XXIV.

SECT. XXIV.

How Powder *is made, and ſeveral ways to know whether* Powder *be decayed or no, by moiſture or Age, in part, or in whole.*

POwder was always made of Salt-peter, Brimſtone, and Char-cole; but in theſe latter times experience hath ſtill mended the goodneſs or ſtrength of it more, than it was in former times by much: but briefly thus; the beſt ſort that is made at this preſent time is made of ſix parts Salt-peter, Brimſtone, Char-cole, one part.

the Muſquet or Piſtol *Powder* is now commonly made of Salt-peter five parts, one part of Brimſtone, and one of Cole; *Canon-Powder* of Salt-peter four times as much as of Brimſtone, and as of Cole. The reaſon why Piſtol-*Powder* being the ſtrongeſt of 6 — 1 — 1 is not ſo good for the *Canon* as 4 — 1 — 1 the weakeſt, although you take but ſo much of the Piſtol *Powder* as you find by an Engine to be of like ſtrength with another quantity of *Canon-Powder*.

The reaſon why *Canon-Powder* is beſt for *Ordnance*, is, becauſe it taketh up a greater room in the *Cylinder* of the *Piece*, than Piſtol-*Powder*; for in taking up much room it hath the greater length or fortification of Metal about it in the *Piece*.

Suppoſe a *Saker* require four *l.* of great *Powder* for her loading, and I would know how much Piſtol *Powder* is equal in ſtrength to four *l.* of *Canon-Powder*, trying by an Engine made on purpoſe to try *Powder*, I find 3 *l.* of Piſtol-*Powder*; therefore you eaſily concieve, that 3 pounds have but 3 quarters of the Metal of the *Piece* to keep it from breaking, when 4 pound had a quarter more Metal, than the other had.

Nath. Nye Mr. *Gunner* found by an experiment made by him at *Deriton* the 17 of *March* Anno 1644, he loading a *Saker-bore Piece* of Iron, and the thickneſs of the Metal about the Chamber was 2 *inch.* and load her with 4 pound of weak *Canon-Powder*, which filled the *Cylinder* of the bore 9 *inch.* juſt, which 9 *inch.* in length, and two *inch.* in thickneſs is 225 *inches* of Metal about the *Powder*, which was 6 ounces more than the *Piece* ſhould have had in proportion to Piſtol-*Powder*: He fired, and the *Piece* went off ſafe; and he ſaith, he loaded her again with one pound and ¼ of fine *Powder* almoſt, which filled the bore but 2 *inches* and ¼, and had to its Fortification but 6, 8 ¼ *inches*, which in weight is 15½. and when the *Gun* was diſcharged, it broke into divers pieces, as there is witneſs enough in that Town. 47 Pound of Metal.

The harder the Corns of *Powder* are in feeling, by ſo much the better it is. Secondly, *Gun-powder* of a fair Azure or French Ruſſet colour is very good, and it may be judged to have all its Receipts well wrought, and the proportion of Peter well refined. Thirdly, Lay 3 or 4 Corns of *Gun-powder* upon a white piece of Paper, the one three fingers diſtant from the other, and fire one, if the *Powder* is good, they will all fire at once, and leave nothing but a white chalky colour in the place where they were burned, neither will the Paper be touched; but if there remains a groſneſs of Brimſtone and Salt-peter, it is not good. Fourthly, If you lay good *Powder* on the palm of your Hand, and ſet it on Fire, it will not burn you. Fifthly, To know the beſt amongſt many ſorts of *Powder*, make a little heap of every ſort, and then ſetting thoſe heaps one from the other, mark well when you put Fire into them, which of the heaps did take Fire the ſooneſt; for that *Powder* that will ſooneſt be on Fire, ſmoak leaſt, leave leaſt ſign behind it, is the beſt ſort of *Gun-powder*. How to know good *Powder*.

Sect. XXV.

How to make an excellent good Match *to give Fire to any* Ordnance.

TAke Cords made of Hemp that is not very fine, or of Tow which is better, (although it will conſume ſooner,) and twiſt it until you have made the Srands as big as a mans little Finger; this done, boyl the ſaid Cords in ſtrong Lye aſhes, and a little Sal-peter, until all the Lye be waſted, and then make it up, and take the *feces* or remainer into your hand, and with the other draw the Match through twice or thrice, then drie it, and keep it for ſpecial uſes, for Vaults, Mines, and moiſt weather, and it is very fit for your uſe any where.

Sect. XXVI.

How to make Powder *it ſhall not waſt with time, and preſerve that as is good to keep it from decaying.*

THat time ſhall not waſt it, take what quantity of *Powder* you will, and mix it with Brandy, and make it up in Balls, and drie them well in the Sun, or in a warm place, and keep them in Earthen Pots well glazed until you have cauſe to uſe them; this *Powder* will not waſt with age, nor decay.

To preſerve *Powder* that is good, all *Gunners* have, or ſhould have that reaſon to keep their *Powder* and *Store* in as good a drie place as is to be had in Fort or Ship convenient, and every Fortnight or at moſt three weeks turn all the Barrels, and Cartredges Barrelled up for readineſs, turn them upſide down, ſo will the Peter be Diſpert into every place and part alike; for if it ſhould ſtand long, the Peter will deſcend downwards always as it lies, and if it is not well ſhaked and moved, it will want of its ſtrength at top very much, and one Pound at bottom with long ſtanding, will be ſtronger than three at the top; keep all Cartredges which are filled for the *Piece* againſt he is hot in Barrels by themſelves, that you may know them by a mark when need requires.

Sect. XXVII.

To renew and make good again any ſort of Gun-powder *that hath loſt its ſtrength by long lying, or moiſture, or any other means.*

FIrſt moiſten the ſaid *Gun-powder* with Vinegar or fair water, beat it well in a Mortar, and then ſift it through a fine Sieve, or a Search, with every *pound* of *Gun-powder* mingle one *ounce* of Salt-peter that hath been mealed; and when you have ſo done, beat and moiſten this mixture again, until you ſee by breaking, or cutting with a Knife that there is no ſign of Salt-peter or Brimſtone in it; moreover, corn this *Powder* when it is incorporated with the Peter as it ought to be; then prepare a Sieve with a bottom of thick Parchment made full of round holes; then moiſten the *Powder* which ſhall be corned with Water, put the ſame, and alſo a little Boul into the Sieve; and when you have ſo done, ſift the *Powder* ſo as the Boul rolling up and down in the Sieve may break the clods of *Powder*, and make it by running through the holes to corn; and if it will not go through, you muſt beat it again until it will.

SECT. XXVIII.

To make Powder *of divers Colours, and first to make* White Powder.

TAke of Salt-peter 12 parts, of Brimstone two parts, and of Camphir one part, beat, and sift, and incorporate all these things together; and after you have so done, beat them again, and so oft until you are sure they are well incorporated, then moisten it with *Aqua Vitæ*; and when you have thus done, corn the *Powder*, as you are taught before.

To make Red Powder.

Take the same things, and work them as before directed for *White Powder*, and as that was moistned with *Aqua Vitæ*, now you must moisten this with Vineagar, being Red as Blood, which will make the *Powder* likewise so in moistening of it, and then corn it, as is before taught.

To make any Coloured Powder.

Boil the Vineagar in such transparent Colours as you would have the *Powder* to be of, as if Blew with Blew Bice, of Green with a little Verdigreace, and the like: always take care that the Colour be not too thick, but very thin, or else it will weaken the *Powder* that you do make.

SECT. XXIX.

Of several sorts of Salt-peter, *and a way how to make a sort of* Salt-peter *very excellent, with ease, and less cost than any way.*

ARtificial Salt-peter is a mixture of many substances gotten with Fire and Water out of drie Dirt and Earth, as out of Vaults and Tombs, and also Charnel-Houses; the best of all is of Beast-dung converted into Earth, in Stables, or Dunghills of a long time not used; and when it is to be made, it is made with a great deal of Charge. Another excellent sort of Salt peter is made on Flower that is called Plaster that groweth on Walls four parts, of Unslak'd Lime one part, and so boiled over the Fire with Water, which is to no purpose to make relation how for to make full direction will fill my lived sheets too fast; but this one way, which is the most easie and least cost, I will write the Receipt thereof, which is this.

Take quick Lime, and pour warm Water upon it, and let it stand six days, stirring it twice or thrice a day; and take the clear of this Water, set it in the Sun until it be wasted, and the Salt-peter will remain in the bottom. To refine Salt-peter, and make it fit for use, there is several ways, but this by Fire I shall only write thereof. Do thus: take an Iron Pot or Skellet, and fill it with Peter, set it on the Fire, and cover it close with an Iron Cover on the top, or with a Stone; when the Salt-peter is melted, take Brimstone most finely beaten, and cast some thereon; kindle it, and let it burn until all the upper part be burned, which when effected, will leave the Salt-peter close like to a piece of Marble, for the Brimstone will burn up the gross victiousnes of the Salt-peter; It is to no purpose to give a further relation of this, by reason every *Gunner* may have his Peter ready made refined and in Meal at the Powder-mens, or Chandlers; or if he is constrained to make Peter or *Powder*, he may have several Books which give a full and large description of the making thereof, as *Nath. Nye Tarta glia*, or *Norton's*; but for what is useful for a *Gunner* in particular, is sufficiently spoken already; therefore let it suffice now, having shewed sufficiently how to make *Powder*, and trie the strength of *Powder*; to know what *Shot* and *Powder* is meet for every *Piece*, to find whether the *Piece* be true bored or not, to load a *Piece* with discretion, if not true bored to make the Dispert; and also to know the difference betwixt Iron and Brass *Pieces*. I shall come to touch how to make a good *Shot* either of Point-blank, or at Random, with as much ease and plainness as ever was taught by any before.

SECT. XXX.

Sect. XXX.

How to Load and Fire a Piece *of* Ordnance *like an Artiſt.*

BEfore we ſhoot at a Mark, it is beſt to Load our *Piece*, in which, firſt obſerve the Wind, and be ſure to lay your Budge-Barrel, or Cartredge of *Powder* to Windward of your *Piece*, and place your Linſtock to Lee-ward, clear the Touch-hole, and Spunge her well, and ſtrike the Spunge on the Muzzle to ſhake off the foulneſs two or three blows.

Then let him ſtand on the right ſide of the *Gun*, and hold the Barrel, ſo that his aſſiſtant may thruſt in the Ladle; being full, give it a ſhog, then ſtrike off the heaped *Powder*, he being on the right ſide likewiſe, with his Body clear of the Muzzle, put the Ladle home to the Chamber ſtedily holding your Thumb upon the upper part of the Ladle-ſtaff, then turn the Staff until your Thumb be quite under it, and give a ſhake or two to clear the *Powder* out of the Ladle; as you hale him out, keep him up that you may bring no *Powder* out with the Ladle; then with the Rammer put the *Powder* home gently, and after put in a good Wad, and thruſt it home to the *Powder*, and give it two or three ſtroaks, to gather the looſe *Powder* together, and it will fire the better; be ſure your aſſiſtant have his Thumb on the Touch-hole all this while; then put in the *Shot* with the Rammer home, and after him another Wad, and then with the Rammer give two or three ſtrokes more to ſettle it home, that there may be no vacuity between the firſt Wad Bullet, and laſt Wadde; your Budge-Barrel and your ſelf ſtanding to Windward always, and your *Piece* by the Diſpert directed to the Mark, Prime her, and let the *Powder* come from the Touch-hole to the Baſe-ring, your Leg ſtanding forward, and fire the *Powder* on the Baſe-ring, and draw back your Hand, and you have fired like the beſt of *Gunners*; but if you had given fire upon the Touch-hole, the *Powder* there would have endangered to have blowed the Cole and Linſtock and allou of your hand; therefore you muſt have a care of a great Touch-hole.

Sect. XXXI.

The difference of Shooting *by the Metal, and by a Diſpert by a Right Range, and at Random, by the Figures following.*

Shooting by the Metal.

SHooting by the Metal is the Figure A B, that is, admit you raiſed the Muzzle-ring, and the Baſe-ring, and the Mark, and your Eye in a Right-line, if you put the Scale into the Muzzle with the Plummet hanging to it, you ſhall find it differ 4 or 5 or 6 *degr.* according to the length or Mark of the *Piece*, and in regard of the ſeveral differences of the length and marks, or *Diameter* of her Baſe and Muzzle-ring, no certain proportion can be generally aſſigned; yet for moſt *Pieces* it hath been well obſerved, that the *Piece* directed by her Metal, will ſhoot about twice as far as when the Mark is level and ſet by a Diſpert & Quadrant and the Sight-line parallel to the Horizon; ſo that admit a *Piece* were laid by the Metal of Baſe and Muzzle-ring, and that it differed from a right Level 6 *degr.* as you found by your Quadrant in the Scale, you fired at the Mark, the *Gun* ſo layed, and meaſuring the diſtance you find it 412 Paces, which is as much beyond the Mark, as it is to it, which is the difference of Shooting by the Diſpert or *Axis* of the bore in right bored *Pieces* following, this is chlled Point-blank; for if you acknowledge the higher the Muzzle of a *Piece* is elevated, the farther the Shot is carryed in a Right-line. There can be no Point-blank directly known, nor Rules to know them, without you take a *Piece* and make 11 Shots out of her, and ſo by it proportion a Table, as here is one following. You muſt have leave, if poſſible, to Shoot ſo many Shots in a *Piece* at ſuch elevations with the like goodneſs and quantity of *Powder*, as will make you ſuch a Table of the Proportions of Right Ranges, called Point-blanks, before you can have any gueſs certainly of Proportion for other *Guns*; but to make a good Shot at a Mark, firſt be ſure your *Guns* Trunnions be placed right, the Carriage well made, the

of Shooting by a Diſpert.

Platform

Platform clean ſwept, and that the ground be Level, and that the Carriage-Wheels be one as high as the other, and whether the Axle-tree be placed juſt acroſs the Carriage, or not; or whether the *Piece* be true bored or not, if it be a true bored *Piece*, ſet your Diſpert on the Muzzle-ring, juſt over then Centre of the Muzzle of the *Piece*, which may be done by holding a Line right before the Muzzle, and two Sticks or Notches made in Sticks put on the Muzzle-ring, and by the Line you may eaſily find the middle where to put the Diſpert; and likewiſe if the Line touch the upper ſide & lower ſide of the Metal alike, you may be ſure the *Gun* lies Level, or by the Scale and Quadrant on it and Plumb-line, if it hang in the Mouth of the *piece*, and no degrees of Altitude, but by the Long Side-line thereof, be ſure the *Piece* is Level, and will carry the Bullet Horizontally in his violent Courſe; therefore by your Crows and Standers by, or Matroſſes ſet about the *Piece* to the Mark, as at D, that with your Eye two *foot* from the Baſe-ring you may ſee the Mark on the upper part of the Baſe-ring, the top of the Diſpert, and the Mark or Turret you Shoot at in a Right-line, as CD, and this you may call Point-blank, and all Shooting in this Form, and no other.

A Table of *Point-blanks.*

deg.	*randons*
0	192
1	209
2	227
3	244
4	261
5	278
6	285
7	302
8	320
9	337
10	354
20	454
30	693
40	855
50	1000

On the upper part of the Baſe-Ring, the top of the Diſpert, and the Mark or Turret you Shoot at in a Right-line, as CD; and this you may call Point-blank, and all Shooting in this form, and no other.

To Shoot in a Right-Range, that is, as far as the Bullet doth go in a Right-line at any Degree of Elevation.

But for Shooting in a Right-line called the Right Range of a Bullet out of any *Piece* for making of Batteries, or Shooting at Random at any advantage, you may make uſe of this Table, until by your own experience, you have made out of a *Gun* by Shooting firſt Level, and afterward from *degree* to *degree* to 10 *degrees* mounture, or more in a Right-line.

By the Rule of Proportion.

The uſe of the Table of Right-Ranges, or Point-blanks before-going, it is found by experience, that the *Piece* aſſigned at ſix *degrees* of mounture Shoot 200 Paces in a right or inſenſible crooked Line; I deſire to know how far the ſame *Piece* will Shoot in a ſtraight Line, being mounted to 10 *degrees*? ſay by the Table if 285 the Number againſt 6 *degrees* giveth 200 paces, what will 354 the Number againſt 10 *degrees* give? I anſwer, 248 $\frac{4}{10}$ paces.

Paces.
248 ,239519
d.
10:354,254900
200,230703
Sum 485003
285,245484

The Logarithm of 6 *degr.* is 285. ——— 245484
The Logarithm of the Paces known 200 ——— 230103
The Paces againſt 10 *degr.* is 354 is ——— 254900
The Sum ——— 485030
give the Logarithm of 248 $\frac{4}{10}$ Paces ——— 239519

Which done backwards, is 6 *degr.* againſt 285 in the laſt Table.

Or extend the *Compaſſes* from 285 to 200, the ſame diſtance will reach from 354 to 248 $\frac{4}{10}$ Paces as before $\frac{200 \times 354}{285}$ = = = 248 $\frac{4}{10}$ Paces, as before.

And the Figure is from E the top of the Caſtle to F the ſide of the Tower at 10 *degr.* mounture, carries the Bullet violently 248 Paces.

SECT.

Sect. XXXII.

How to Order and Direct a Piece, *and amend an ill Shot that was made, either by the Metal, Level, Right-line, or Advantage, or Mount.*

After you have made one Shot, and find the *Piece* carry just over the Mark, then do all as hath been before taught again; and when your *Piece* lies directly against the Mark, observe how much the last stroke of the Shot is above the Mark, so much longer make your Dispert, that the top of it may be just seen from the Britch of the *Piece* in a direct Line with the stroke of the Shot; and being so fitted, Level your *Piece* with this new Dispert to the assigned Mark, give Fire, and without doubt it will strike the same; if the first Shot had struck under the Mark, then bring the *Piece* in all points, as before; mark how much of the Dispert is over the Shot, and cut it just so short, as being at the Britch, you may discern the top of it, the Mark of the Base-Ring, and the stroke of the Shot in a Right-line, when you percieve it is of such a length, Level the *Piece* to the intended Mark as at the first, Prime, and give Fire.

If the first Shot had struck on the right Hand of the Mark, to mend it, you must Level the *Piece* as formerly, you standing behind the Britch of the *Piece*, observe the stroke of the Shot over the Dispert, that part of the Base-ring which you at that instant looked over in a Right-line towards the Dispert, and the stroke of the Shot, set up a Pin with a little soft Wax on the Base-ring, so this Pin will be in a Right-line with the Dispert and stroke, then Level your *Piece* to the Mark intended by this Pin, and the first Dispert, and without question you will make a fair Shot; for when you Level by the Metal of the Base-ring where the Pin is placed and the Mark; the Piece standing at that direction, look over the top of the Dispert from the Mark in the Base-ring, and you shall find the *Piece* to lie just so much to the left, as the former Shot struck to the right, from the intended Mark, which should in all likelihood now strike the Mark.

But if the Shot be both wide and too low, then you must use both directions, as before taught to make the next Shot; first regulate the Dispert by cutting it shorter, according as the Mark of the Shot is lower than the intended Mark, then by the last Rule mend the Shooting wide; these things done with care and diligence, you may be sure will mend a bad Shot.

Sect. XXXIII.

Of Shooting upon the Advantage or Random, at a Mark, beyond the Right-line of the Pieces *reach, or Right-range of the Shot, and of the Dead-range for every* Degree.

In the two last Sections we have shewed for the Right-range; now we come to shew for the Dead-range, which consisteth of the right and crooked Range together in one, and then called the Dead-range, which is the whole distance from the Platform upon which the Piece intended or assigned is discharged unto the first fall or graze of the Bullet on the Level-Line, or on the ground called the Horizontal Plain, (by reason the different length of the Piece, and strength of the Powder increaseth or diminisheth the course or fury of the Shot, and therefore more difficult to be found out, but only by Experience, or Diagrams, Tables, or Scales made by Experiment; now it vis ery difficult, and a thing uncertain also to arrive herein unto exactness, without some Experience of the Piece; and therefere every one that will learn to Shoot at Random, must draw his Piece in a Level Ground, where first Shooting Level, he must observe that distance in Feet and Paces; then Mount his Piece to one *degree*, and mark where that shall Graze, and thus find the distance of every *degree* from the Level to the 10 *degree*, and by these distances make a Table, to which

annex

annex the *degrees* againſt the diſtances, by which Table, and the Rule of Proportion, or Logarithms, or Line of Numbers, find how far another *Piece* will convey her Shot from *degree* to *degree*; but in caſe you cannot have the Liberty, nor *Powder* to do the aforeſaid, you ſhall have a Table here that was made out of a *Saker* eight Foot long (by *Nath. Nye*, as in the 40th. Chap. of his Book,) where he ſaith, he Loaded her with three Pound of *Powder*, the Shot at one *degree* of mounture was carryed 375 Yards, or 225 Paces; the next Shot was at five *degrees* Random, and at that mounture the Shot was conveyed 416 Paces; and the next tryal was at ſeven *degrees* mounture, and the Random produced 505 Paces; the laſt tryal was at 10 *degr.* mounture, which ſent the Shot 630 Paces of five Fort to a Pace.

Whilſt he made theſe Shots, he loaded the *Piece* himſelf with looſe *Powder*, exactly weighed, and weighed the Wad alſo, and beat down the ſaid Wad with four ſtrokes ſo near as he could by the ſame ſtrength, as he did the time before; alſo he let the *Piece* cool betwixt each Shot of it ſelf, ſtaying above half an hour betwixt each Shot, he put no Wad after the Bullet, becauſe the *Piece* was mounted, he tryed the ſtrength of his *Powder*, and noted it down, to compare with other *Powder*, to know its ſtrength by; and that is the way all *Gunners* muſt take, that intend to make good Shots at Random. All Mr *Gunners* ſhould be able to draw an exact Deſcription of the ſaid Garriſon, and every object as lyeth near his Works by the Rules of the 7th. Chap. of the *Art* of *Surveying* by the *Sea-Compaſs* in this 5th Book; ſo that he may know what is within reach of his *Guns*, by which means he ſhall not be troubled to take Diſtances, but be ready at all times to know his Diſtances by his Maps: then after he hath made one Shot, he may make another Shot to any Diſtance he pleaſeth.

Example.

Suppoſe I know the Diſtance by my Map where the firſt Shot grazed to be 704 Paces, as you may ſee by the Figure out of the lowermoſt *Gun* of the Caſtle from S to the graze at A, the mounture of the Piece being 4 *degr.* how much muſt I mount the *Piece* to convey her Shot 900 Paces, as you may ſee by the Figure B the *Gun*, to C the Shots graze, or place required.

You muſt proportion theſe Diſtances of Random, to thoſe in the Table following; ſaying, if 704 Paces require 370 Paces, as is in the Table at 4 *degrees* of Random, what number will be found againſt the *degree* in the Table; I muſt Mount the *Piece* unto 900, and work by theſe Rules.

$$\frac{370 \times 900}{704} ==== 473$$

Extend the *Compaſſes* from 704 to 370, the ſame will reach from 900 to 473.

The Logarithm of the Shot made 704 is —— —— 284757
The Logarithm in the Table againſt 4 *degr.* is 370) — 256820
The Logarithm of 900 Paces Random is —— —— —— 295424
The Sum is —— 552244 gives the Logar. of 473 Paces, which I look for in — 267487 the Table of Randoms, but find no ſuch number there, but the next leſs is 461, and the next greateſt is 550 againſt 7 *degrees*, the difference betwixt theſe two Numbers, is 44 and 461 is 12 leſs than 473, and 12 is almoſt the one fourth part of 44, and therefore it ſhews that the *Piece* muſt be mounted at 6 *degr.* 15 *min.* or one Quarter to reach the Diſtance of 900 Paces as from B or *b* to C.

505 − 461 = 44
505 − 473 = 32

A Table of the proportion of dead Ranges.

Deg.	*Randoms.*
0	206
1	225
2	274
3	323
4	370
5	416
6	461
7	505
8	548
9	589
10	630

Here is a Table of Randoms that was made out of the fore-named *Saker* of 8 Foot long, and loaded with 3 Pound of *Powder*, and every *Gunner* is adviſed, it poſſible, to get *Powder*, to make one by his own experience, and always to keep ſome of the ſame *Powder* to try his Proportions by; the Rule in the 24 Section by any other *Powder* he ſhall have occaſion to uſe, for this is 1 of the material things belonging to a *Gunner*, without which knowledg hec an never make a good Shot; for at the time of a Leagure he muſt expect often to change his *Powder*, as ſometimes you ſhall have 9 Pound of one ſort as good as 15 of another ſort, as by Inſtrument and Shooting you may have experience.

Sect. XXXIV.

How to make an effectual Shot out of a Piece *of* Ordnance *at Random.*

EVery one that hath Charge of a *Gun*, muſt at one time or other get leave of his Commanders to make two or three Shots at leaſt out of the ſame Piece, and meaſure the Diſtance from the Platform to the firſt graze of the Shot, you muſt apply it to this Table by the laſt Rules of Proportion in the laſt Section, and find what *deg.* you ſhall need Mount the *Gun* to for any other Shot at any other time, when you ſhall have occaſion; when you have Loaden your *Piece*, as you are directed in Sect. 32, take the Diſtance to the Mark in the XVI Chap. of the ſecond Book of the Deſcription and Uſe of the *Quadrant* I have ſhewn you; and alſo obſerve how many *degrees* the Platform is higher or lower than your Mark by your *Quadrant* on the back-ſide of your *Scale*; after you have done that, then Calculate by the laſt Rules what *degree* the *Gun* muſt be Mounted to, to reach the Mark, if the ſaid Work be under the Platform, Subſtract the Difference found by your *Quadrant*, out of the *degree* of the Random; but if the ſaid Mark be higher than the Platform, Add the *degr.* of that Altitude to the *degree* of the Random, and at theſe corrected *degrees* Mount your *Piece.*

How to Mount your Piece *by your* Scale *and* Quadrant *thereon.*

The uſe of the *Quadrant* on back-ſide of the *Scale* in the third Chap. for the Mounting of the *Piece.*

To the ſide of the *Scale* or *Quadrant* is a piece of Braſs fitted of the ſame breadth, with two Screws, and holes fitted to ſcrew the Braſs Plate two *Inches* of the former length, without the Edge or Side of the Line of Numbers, for to take any Angle that is under the Line of Level; for if you put the Braſs into the Mouth of the *Piece*, the Line of Numbers being next unto it, and put in the Tompkin into the Mouth likewiſe to ſtop it faſt in the middle of the Metal at the bottom, and then the ſtanders by raiſe the Britch with Crows to what *degree* you pleaſe; and ſo likewiſe if the Mark or *degr.* aſſigned be above the Line of Level, if the *Scale* will not ſtand faſt by the *degree* of the *Diameter* that fits the Bore, putting of it juſt into the Mouth of the *Piece*, then ſcrew the Braſs Plate to a hole made on purpoſe for the other ſide, and turn the *degrees* of the *Diameter* to the Bore, and faſten it with the Tompkin in the middle of the Mouth, as before; and ſo this Inſtrument will be moſt uſeful for all things as belong to a *Gunner*, with leſs trouble and Charge, than any other that ever was made by any other Men, and far more uſeful.

Then the Inſtrument being in the Mouth of the *Piece*, as before directed, mark diligently until the Plumb-Line, which proceeds from the Centre of the *Quadrant*, cut theſe aſſigned *degrees* and Parts of *degrees* that you are to Mount the *Gun* by, in the Arch which is Divided into 90 *degrees* in the outward Circle thereof; your *Gun* ſo Loaded and fitted, as beforeſaid, make your Shot, for without queſtion, you will make a good Shot, and ſtrike or came near the Mark.

As

As for *Example.*

Suppoſe you make tryal of your *Gun* as is ſpoken of in the laſt Section 32, you find that at 4 *degrees* of Random upon a Level-Ground the Shot is conveyed 704 Paces, if you be called out in haſt upon Service againſt a City, or other Fort, and being appointed to play your *Gun* towards it, you alſo find it to be beyond the reach or the Right-range of your Shot, and the Diſtance being 560 Paces; and alſo that the place is lower than where you can Plant your *Gun* by one *degree* and $\frac{1}{6}$ or 10 *min.* then to know the *degree* of Mounture, you may work as by the laſt Rule, if 704 gives 370 againſt four *degrees*, what will 560 give? the Diſtance to the Mark, it will give you the Number 295; look for this Number in the laſt Table 295, or the neareſt Number to it, and againſt that *degree* and Part of a *degree*, which muſt alſo be found by Subſtracting the neareſt leſs Number out of the neareſt great Number, the greateſt Number in the Table is 323, the neareſt leaſt is 274, the Difference is 49, the difference betwixt 323, and 295, is 28, the half of 49 is 24$\frac{1}{2}$, which ſhews that *degree* is 2 and a little above $\frac{1}{2}$ of Random; but becauſe the Mark is lower than the Platform, Subſtract one *degree* $\frac{1}{4}$ or 10 *min.* out of 2 *degr.* 32 *min.* and the Remain is 1 *degr.* 22 *min.* the true height the *Piece* muſt be elevated, to reach the Mark; but if the Shot graze to the right or left, you are to mend it by direction in Sect. 31, but ever by the Example or Direction there.

Suppoſe the Shot graze over the Mark 20 Paces, Subſtract this 20 out of 560 the Diſtance, and Mount the next Shot according as if the Mark were but 540 Paces diſtant, if 20 Paces too ſhort, make the next Shot as 580 Paces, that is the *degree* that is found by that Proportion to reach ſo far.

SECT. XXXV.

How to find the Right-Line, *or* Right-Range *of any* Shot *diſcharged out of any* Piece, *for every elevation by one* Right *or* Dead-Range *given for the* Piece *aſſigned.*

FIrſt, you muſt have the help of this Table of Dead-Ranges, which was made by Experience of Mr. *Norton*, and the Table of Point-blanks, or Right-Ranges, was the ſame Shots in a Right-line at every *degree* of Mounture, as this Table is the Dead-graze of the Bullet at the ſame Shot with the ſame *Gun*, for he made 200 Shots for tryal.

You may make uſe of this Table by the ſame Rules in the 32 Sect. and Table of dead-ranges.

Now although it be a thing very difficult, and likewiſe uncertain to arrive herein to exactneſs, without ſome Experiments made with the aſſigned *Piece* and *Powder*; yet to come to a neceſſary nearneſs at firſt, far ſurer than by uncertain gueſſing by this Table, or by my Scale, and the Rules therein directed.

As for *Example.*

Admit you were to ſeek the Right-Range of a Bullet, that the *Piece* was fired at 30 *degrees* Mounture, and the Dead-Range of the Bullet was known to be 2200 Paces.

$$\frac{2200 \times 693}{2150} = 710 \text{ Paces.}$$

A Table of Proportion of Dead-Ranges.

Degr.	Paces.
0	192
1	298
2	404
3	510
4	610
5	722
6	828
7	934
8	1044
9	1129
10	1214
11	1296
12	1394
13	1469
14	1544
15	1622
16	1686
17	1744
18	1792
19	1849
20	1917
25	2013
30	2150
35	2249
40	2289
42 1/2	2296
45	2289
52 1/2	2283
60	1792

Or look in this Table of Dead-Ranges againſt 30 *degrees* is 2150) ——— 333243

And the Dead-Range given or known for 30 *degrees* to be 2800 Paces. ——— 334242

The Number againſt 30 *degrees* in the firſt Table of Point-blanks 693 ——— 284073

The Sum —— 618315

Gives the Logarithm of 710 Paces for the Right-Range of ——— 285072

The Bullet carryed violently in a Right-Line at 30 *degr.* Mounture.

But admit the Level Right-Range is given, and the Right-Range of 30 *degrees* Mounture be ſought.

Work by theſe Rules.

The Logarithm of Point-blank 0 *degr.* is 192 ——— 228330

The Num. againſt 30 *d.* is 693 in the Table Point-blank- 284073

The Level Right-Range of this *Piece* is 197 Paces —— 229446

The Sum ——— 513519

Gives the Log. of 711 Paces for the Right-ranges required 285189

And as the Numbers are in the Logarithm, ſo you may do by the Line of Numbers.

$$\frac{693 \times 197}{192} = 711$$

711 Paces the Range in a Right-Line.

Sect. XXXVI.

To know how much of the Horizontal-Line *is contained directly under the* Right-Line *of any* Shot *called the* Right-Range *made out of any* Piece *at any Elevation aſſigned.*

BE it propounded to find what part of the Horizontal-Line lyeth directly under the Right-Range of the *Piece* aſſigned at 30 *degr.* Elevation, the Right-Range for 30 *deg.* Mounture, by the laſt Rule is found to be 711 Paces, Work with the Complement of the *Pieces* Mounture 60 *degr.* thus always.

As the *Radius* 90 *degr.* ——— 1000000

is to the number of Paces in the Right-Range 711 Paces ——— 285186

So is the Compl. Sign of 30 *degr.* Mounture, which is 60 *degr.* —— 993969

to the Logarithm of the Horizontal-Baſe 619 Paces ——— 279155

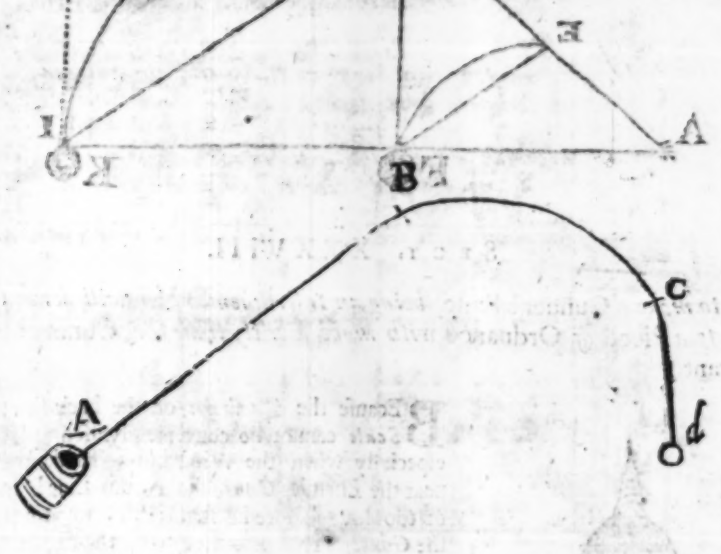
Now you find that 619 Paces lies under the Right-Range of the Shot, you may preſently find how much of the Horizon is contained under the Crooked-Range of the Shot, if you Subſtract 619 the Horizontal Diſtance out of 2200, the Randoms at the firſt graze of the Bullet from the *Piece*, the Remainer is the Horizontal Diſtance 1581 Paces, which lies under the way of the Shot, as it goeth helically between the Right-Range, and the natural or perpendicular motion, or before it make the firſt graze; the like in all other queſtions.

Sect. XXXVII.

SECT. XXXVII.

Of the violent, crooked, and natural Motion or Courſe of a Shot *diſcharged out of any* Piece *of* Ordnance *aſſigned.*

BY the third and fourth Propoſition of the ſecond Book of *Tartaglia*, his *Nova Scientia*, ſhews that every body equally heavy, as a Shot in the end of the violent motion thereof, being Diſcharged out of a *Piece of Ordnance*, ſo it be not right up, or right down, the Crooked-Range, ſhall join with the Right-Range, and to the natural Courſe and Motion betwixt them both.



As for *Example.*

The Right-Range being all the Right-Line A B which is properly called his Violent Motion, and B C will be the mixt or Crooked-Range, and C D the Natural Motion, wherein from A to B is the furtheſt part of the Violent Motion, and from C to *d* the end of the Natural Motion.

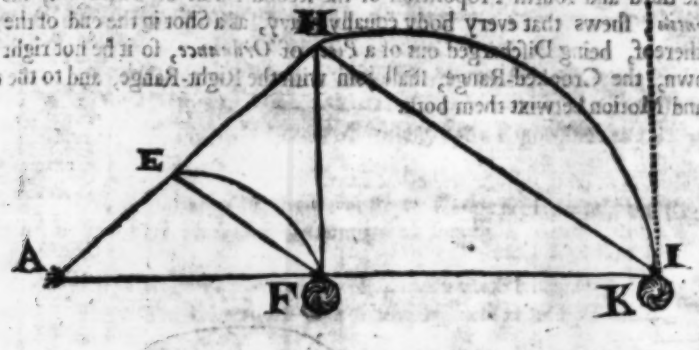
And in the ſeventh Propoſition of the ſame Book, he proveth that every Shot equally heavy, great or little, equally elevated above the Horizon, or equally Oblique or Levelly directed, are among themſelves like and proportional in their Diſtances, as the Figure following ſheweth, as A : E : F is like and proportional in the Right and Crooked-Ranges unto H : I, and in their Diſtance or Dead-Ranges A F unto A: I.

And in his fourth and ſixth Propoſitions of the ſame Book, he proveth that every Shot made upon the Level hath the mixt or Crooked-Range thereof, equal to the Arch of a *Quadrant* 90 *degr.* and if it be made upon any Elevation above the Level, that then it will make the Crooked-Range, to be more than the *Quadrant.*

And if that be made Imbaſed under the Level, that then the Crooked-Range thereof will be an Arch leſs than a *Quadrant.*

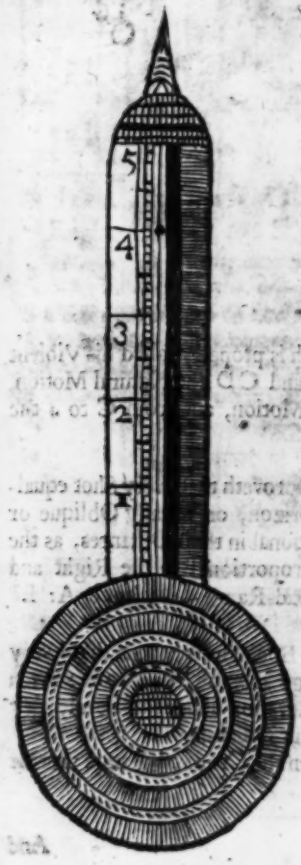
And

And laſtly, in his ninth Propoſition of the ſame Book, he undertakes to prove, if one *Piece* be Shot off twice, the one Level, and the other at the beſt of the Random at $42\frac{1}{2}$ *degr.* Mounture, that the Right-Range of the length is but $\frac{1}{2}$ of the Right-Range of the beſt of the Randoms, and that the Dead-Range of the Level is but $\frac{1}{3}$ of the Dead-Range of the beſt Random, whereto he that deſires a further Demonſtration of theſe Propoſitions in his ſaid ſecond Book of *Nova Scientia.*



Sect. XXXVIII.

How to make a Gunner's Rule, *being an Inſtrument which will ſerve to elevate a* Piece *of* Ordnance *with more facility than the* Gunner's Quadrant.



BEcauſe the *Quadrant* on the back-ſide of the *Scale* cannot be conveniently uſed at all times, eſpecially when the Wind blows hard, and being near the Enemies *Guns*, the Plumb-Line is ſo long, or too long before he ſtands ſtill; to remedy this, the *Gunner's* Rule was invented; the Figure thereof you may here ſee; this Ruler muſt be 10, or 12, or 14 *Inch.* long according as the *Gun* will require, it muſt have a long ſlit down the middle thereof like an Eye-vane of a *Quadrant* or *Back-ſtaff*, the Head thereof make Circular according to your *Gun*, as you ſee in the Figure; the Inſtrument is deſcribed ſtanding upon his Britch of a *Piece* of *Ordnance*; in the middle of the ſmall narrow ſlit you muſt place a Lute-ſtring, a well twiſted Thrid, or Silk-ſtring may ſerve; this Bead muſt be ſet to ſuch an *Inch* and Parts, as you find is agreeable to ſuch a *degr.* as you muſt Mount your *Gun* unto, and on one ſide the ſlit you muſt place a Diviſion of *Inches*, and every *Inch* into 10 Parts Divided, and thus it will ſerve for all ſorts of *Guns*; but if it be for a particular *Gun*, then on the other ſide you may place the *degr.* and *min.* when you ſhall find by the length of your *Gun*, how many *Inch.* and Parts goes to make one *degree*; but to uſe it with all ſorts of *Ordnance*, let it only be Divided into *Inches* and Parts, the Bead ſtands at *Inch.* four in the Rule.

Sect.

SECT. XXXIX.

How to Divide the Gunner's Rule *into* degr. *by help of a Table, fitting it for any* Piece *from* 5 foot *long to* 14 foot *long; and by the help of this* Table, *any* Piece *may be Elevated to any* degr. *without the help of a* Quadrant, Ruler, *or any other* Geometrical *Inſtrument whatſoever.*

TO fit the Ruler for one *Gun* only, here is the Rule for the Deviation of the *degr.* Note, this Table hath 11 Columns, the firſt ſhews the length of the *Piece* in Feet and half Feet, the other 10 in the Head is 10 *degr.* and under is *Inches* and the 100 part of an *Inch*, from 1 *degr.* to 10 *degr.* and ſo you may take them out of the Table, and ſet them on the Rulers oppoſite ſide.

The uſe of the Table

If your *Gun* be 8 Foot long one *Inch* $\frac{41}{100}$ makes one *degree*; your *Gun* 12 Foot long 5 *Inches* $\frac{3}{10}$ makes 2 *degrees*.

Or you may ſet your Bead to 5 $\frac{3}{10}$ *Inch*, to Mount him 2 *degrees*.

The len. of the Piece	1 Degree.	2 Degrees	3 Degrees	4 Degrees	5 Degrees	6 Degrees	7 Degrees	8 Degrees	9 Degrees	10 Degr.
Feet and ½ Feet.	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100	*Inch.* 100
5 Foot long.	1 32	63	8 4	11 5	14 6	16 7	19 8	82 9	25 10	28
5 Foot and half.	1 14 2	28 3	42 4	56 5	70 6	84 7	98 9	12 10	26 11	40
6 Foot long.	1 22 2	44 3	66 4	88 6	10 7	38 8	58 9	78 11	8 12	29
6 Foot and half.	1 36 2	72 4	8 5	44 6	80 8	17 9	53 10	89 12	25 13	63
7 Foot long.	1 47 2	94 4	41 5	88 7	35 8	82 10	30 11	77 13	24 14	73
7 Foot and half.	1 58 3	14 4	71 6	28 7	85 9	42 10	99 12	55 14	14 15	71
8 Foot long.	1 68 3	36 5	4 6	72 8	40 10	8 11	76 13	44 15	12 16	82
8 Foot and half.	1 79 3	58 5	37 7	16 9	95 10	74 12	53 14	32 16	12 17	92
9 Foot long.	1 89 3	79 5	68 7	58 9	47 11	37 13	27 15	18 17	8 18	98
9 Foot and half.	2 00 4	06	0 8	0 10	0 12	10 14	2 16	3 18	4 20	4
10 Foot long.	2 10 4	20 6	30 8	40 10	30 12	61 14	73 16	84 18	56 21	8
10 Foot & half.	2 21 4	41 6	69 8	88 11	81 13	28 15	48 17	68 19	89 22	10
11 Foot long.	2 31 4	62 6	93 9	24 11	56 13	88 16	22 18	51 20	82 23	14
11 Foot & half.	2 43 4	87 6	26 9	68 12	10 14	53 16	95 19	37 21	80 24	21
12 Foot long.	2 53 5	67 7	59 10	12 12	65 15	18 17	71 20	25 22	78 25	33
12 Foot & half.	2 63 5	89 10	52 13	15 15	78 18	41 21	4 23	67 26	33
13 Foot long.	3 74 5	48 8	82 10	96 13	70 16	44 19	48 21	92 24	68 27	40
13 Foot & half.	3 84 5	68 8	52 11	36 14	20 27	419	88 22	72 25	56 28	42
14 Foot long.	2 95 5	90 8	85 11	80 14	75 17	70 20	65 23	60 26	56 29	53

SECT.

Sect. XL.

How to give Level to a Piece *of* Ordnance, *with the* Gunner's Rule *at any* Degree *of Random.*

YOur *Piece* being Loaded in all points, as is before taught, and you have brought the *Piece* in a Right-line with the Mark, the Diſpert being placed upon the Muzzle-Ring, in like manner place your Ruler upon the Baſe-ring, and let one ſtanding by hold it, for the Foot of it fitted round to the *Gun*, you may be ſure to put it right, and you may eſtimate on its perpendicular near enough: now having before the Diſtance to the Mark you intend to Shoot at; and admit you have found it to be 461 Paces, and the firſt Shot you made for Practice out of that *Gun*, conveyed her Shot at two *degrees* of Mounture 274 Paces, then according to the Rules in the 32 Section, and the Tables of Random, there I find 461 againſt 6 *degr.* which I muſt Mount the *Gun* to reach 461 Paces.

Then to find by this Table how many *Inches*, and hundred parts of one *Inch* 6 *degr.* will require; look in the Table above, and find on the left Hand in the firſt Column the length of the *Piece* 13 Foot juſt, under 6 *degr.* in the Common-Angle, you ſhall find 16 $\frac{44}{100}$ *Inches*, and to that height I ſet the Bead on the Lute-ſtring, to 16 $\frac{44}{100}$ *Inch*, or 16 $\frac{4}{10}$; for every *Inch* is Divided into 10 Parts, and every Part is ſuppoſed to be Divided into 10 more; then cauſe the *Piece* to be Mounted higher or lower, until you bring the Bead, the top of the Diſpert, and the Mark all in one Line, ſtop the *Piece* in that poſition with a Coyn, Prime, and give Fire.

If you will Shoot by the Metal of the *Piece*, Subſtract the height of the Diſpert out of the *Inches* found by the Table, and the Remainer, Mount your *Piece* unto; if the Diſpert be 3 *Inches* $\frac{1}{2}$ long, Subſtracted from 16: 44 found in the Table, leaves 12 $\frac{19}{100}$, or 12 $\frac{2}{10}$ of an *Inch*, you muſt ſet the height of the Bead to Shoot the ſame Diſtance, by the Muzzle-Ring without the Diſpert.

Sect. XLI.

How by the Table *to give* Level *to a* Piece *of* Ordnance, *without the* Gunner's Rule.

IF you have not a *Quadrant*, nor a Ruler, and would make a Shot at 4 *degrees* of Elevation, look in the Table, and find the length of the *Piece*, which ſuppoſe to be 9 Foot and half, right againſt 9 $\frac{1}{2}$ in the Angle under 4 *degr.* you ſhall have 7 *Inches* to be the length of any Stick, cut, and ſet it upon the Baſe-Ring, and bring the top of the ſaid Stick, the top of the Diſpert, and the Mark in a Right-line with your Eye, and Prime, and give Fire, and you will make as good a Shot, as if you had the Ruler, and Bead, or *Quadrant*; if you will have no Diſpert, take the Diſpert, and Meaſure it upon the foreſaid Stick at the Baſe-Ring, and from it cut off its lenghth juſt, and the Remainer you may uſe upon the Baſe-Ring, and it ſhall mount the *Gun* to 4 *degrees*, as before; and bring the top of the Stick, the Muzzle-Ring, and the Mark in a Right-line, and you may be ſure to make a good Shot; if the Diſpert were 3 *Inches*, that cut from 7 *Inches*, the Remain is 4 *Inches*, for the length of the Stick to be ſet on the Baſe-Ring, for to Level the *Piece* without a Diſpert.

SECT. XLII.

How to make a Shot at the Enemies Lights in a dark Night.

UPon ſuch occaſion, to Shoot at a Light ſeen in the Night, Diſpert your *Piece* with a lighted and flaming Wax-Candle, or with a lighted piece of Match, that with your Eye you may bring the Baſe-ring, the fired Match on the Muzzle-Ring, and the Enemies Light in a Right-line, (or mark) then give Fire, and you will make a good Shot.

SECT. XLIII.

How to make a perfect Shot at a company of Horſe-men, or Foot-men paſſing by the place where Ordnance *doth lie upon a Level-Ground; and alſo to make a good Shot at a* Ship *Sailing upon a* River.

TAke a *Piece* that will reach the way or Mark in a Right-Line that the Horſe or Foot are to paſs by, then your *Gun* Loaded ſo with *Powder* as it may preſently take Fire, and Shot fit for that uſe; and ſeeing a Tree, Buſh, or Hillock, or ſome turning croſs way for his Mark, and when the Enemies come near to that way in a Right-Line with his *Gun*, give Fire: and at Shooting at a Ship in a River, he muſt put his *Piece* to ſome evident Mark on the other ſide the River, and when the Head of the Ship ſhall begin to be betwix the *Piece* and the Mark, and then give Fire.

SECT. XLIV.

How to cauſe the ſame quantity both of Powder *and* Shot, *diſcharged out of the ſame* Piece, *to carry cloſe, or more ſcattering.*

IN the Book of Mr. *John Bate* of *Extravagants*, he ſaith, take the quantity of a Peaſe of *Opium*, and charge it among the Caſe-Shot, and it will make the ſaid Shot flie cloſer together, than otherwiſe it would; for *Opium* is of congealing and fixative nature; this a Sea-man found by experience.

SECT. XLV.

How a Shot which ſticketh faſt within the Concavity of a Piece, *that it cannot be driven home unto the* Powder, *may be ſhot out, without hurt to the* Gunner, *or hurt to the* Piece.

WHen any Piece of Ordnance is Charged with ſuch a Shot as will not be driven home unto the Powder, then the Gunner to ſave his Piece from breaking, muſt ſo Imbaſe the Mouth thereof, or put him under the Line of Level, that fair Water for two or three days being put into the Touch-hole at ſeveral times, may run into a Veſſel ſet under the Mouth of the *Gun*, to ſave all the Salt-Peter that was in the Powder: and then let the *Gunner* clear the Touch-hole, and put in as much Powder as poſſible he can, and Prime, and give Fire, and it will ſerve to drive out the Shot.

But when a Shot hath lain long in a Piece, until he is grown ruſty, and ſo ſtick faſt; put ſtrong Vinegar in the Mouth of the Piece, and with the Rammer ſtrike the Shot until it doth move, then put in Vinegar until it run clear through the Powder and Shot, Prime, as before, and give Fire with good Powder; and if it do not run through after it hath ſtood 3 days, clear the Touch-hole, Prime, and give Fire.

Sect. XLVI.

A Piece *of* Ordnance *at the ſame Elevation, and towards the ſelf-ſame place, with the like quantity of* Powder *and* Shot, *diſcharged ſeveral times, what difference there is in their* Ranges.

THere hath been a *Piece* diſcharged in the ſpace of an Hour ſeaven times, with the like quantity of Powder, Shot, and Mounture, and their Ranges have been found as followeth; the firſt Shot was conveyed 418 Paces, the ſecond 438, the third 442, the fourth 434, the fifth 427, the ſixth 412, the ſeaventh 395; ſo that the greateſt difference from the firſt Shot was 24 Paces; this every *Gunner* muſt take notice of, if he intends to Shoot well at Random; the reaſon of theſe things is this, the firſt Shot of *Powder* found, the Chamber of the *Gun* moiſt, and the Air quiet, the ſecond Shot, the Chamber was dryed, and the *Gun* in a good temper, and the Air moved towards the Mark with the firſt Bullet, and having leſs aſſiſtance than the firſt, went beyond, and made the beſt Shot; and every Shot after, will come ſhorter and ſhorter, as the *Gun* grows hotter and hotter; the reaſon is, by how much hotter the *Piece* is, by ſo much the more attractive is the concavity of the *Piece* made; and becauſe the Shot is driven forth or expelled with no other thing, than by the Air's exaltation, or Wind, cauſed through the Salt-Peter; and therefore the oftner the *Piece* is Fired, and the more heat, the more attractive, which ſuppleth and retaineth continually more of that Wind, which ſhould ſerve to expel the Bullet; and therefore the virtue expulſive in that *Piece*, doth more and more decreaſe, and the Shot flyeth not with that ſwiftneſs, as it did before in the 2 firſt Shots, which dryed and brought the *Gun* into his beſt temper; but the third and fourth Shot is but little difference from the firſt, but the reſt will differ every Shot.

Nicholas Tartaglia doth report, that many Shots being made at a Battery by a *Piece*, it chanced by ſome occaſion, the *Piece* roſe up in ſuch ſort that the *Piece* touched the ground with its Mouth; a little Dog running by, did ſmell into the Mouth of the *Piece*, and after a little time, was drawn almoſt to the further end of the concavity: they pulled him out almoſt dead; this was done by the virtue Attractive.

Sect. XLVII.

How to Weigh Ships *ſunk, or* Ordnance *under Water: or to know what empty* Cask *will carry any ſort of* Ordnance *over a* River.

NIcholas *Tartaglia* hath well collected from the Learned *Archimedes*, and hath calculated the Proportion of Stone, and other Mettals, what they will weigh in the Water, and in the Air.

All Men know by reaſon, that whatſoever is heavyer than ſo much Water, as the body of the Metal thruſteth out of the place, or Veſſel, will ſink; and being lighter than ſo much Water, will ſwim.

Tartaglia ſaith, that ordinary Free ſtone weighing 93 *l.* in the Air, will weigh but in the Water, which is near as 2 is to 1, between the Free-ſtone, and the Water. And that Marble-ſtone that weigheth 7 *l.* in the Air, will weigh but 5 *l.* in the Water, which is near as 7 to 2, between the Marble and the Water.

And Iron and Tin, that in the Air weigheth 19 *l.* will weigh 16 *l.* in the Water; ſo it is as 19 to 3.

Braſs weighing in the Air 65 *l.* will in the Water weigh 55 *l.* and ſo Braſs is to Water, as 65 to 10.

And Lead weighing in the Air 30 *l.* will weigh in the Water but 27 *l.* ſo Lead is to Water, as 30 to 3.

And

And laſtly, Gold in the Air being 17 *l.* in the Water, it will weigh but 16 *l.* ſo Gold is to Water, as 17 to 1. He alſo layeth down Rules to weigh Ships, or Guns, or any thing elſe in the Water, that hath not lain too long, and docked it ſelf in Oaze: for if the thing ſunk be upon Sands or Rocks, it will weigh the better. He deſcribes Veſſels Loaden to be brought to the place where the thing is ſunk, and a Globe of Glaſs put in a Frame of Wood, and a place in the bottom of the Glaſs to put his Head into the concave, he may both ſee and breath, and by a Windleſs Rope, and weight to ſink it, he may firſt let down the weight, and after have himſelf down in that Frame, that is in a form of an Hour-Glaſs, to the bottom of the Sea, and do the work, and ſling the Ship, and Guns, and when he will come up to the top again, to un-wind the Rope, and the Frame will be guided upright, and he and it will come to the top of the water very ſafe, and faſten this Rope brought from the Ships, and un-lead the Veſſels, then will they Buoy up the Ship ſunk, or any thing from the ground.

Briſtol, Septem. 12. 1667 *by experience of a Spaniſh Ship called the* Victory *of* Majork, *ſunk in* Hungrode *at the* Pill; *her Burthen about* 300 *Tuns; we weighed her with* 4 *empty Lighters of* 30 *Tuns a piece, by laſhing the Lighters at Low-water, Head and Stern; and at High-water the Ship we heav'd A ſhore by a Grabble, and did riſe as the Water did flow; and the Low-water or two afterward, the Ship was free, and ſwimmed; the Ship and Water was Eſtimated to weigh* 1000 *Tuns, that the four Lighers weighed; ſhe had no Goods in, but turned over as ſhe was, having done to Carein.*

Or by a Float-Stage & Windleſs, Capſton, and Trunk of Leather made ſo thick, that no Water can come in, and with a pair of Glaſs Eyes faſtned, that no Water can go through, fitted to the Caſe of Leather within, and two Bladders blown at the brim or top of the Water, made faſt to the Caſe of Leather to ſwim, the Mouth of the Caſe, while the Man goes down with Ropes fit to ſling it, and makes them faſt at liberty; then hale him up after a time fit, and by your Veſſels, as before, and Float-Stage, Heave and Buoy up the thing ſunk.

The beſt weighing of Ships, is where the water ebbs and flows much.

Know this, that 5 Tun of Cask will ſwim a *Canon* of 8 or 9000 weight, 4 Tun a *Demi-Canon*, 3 Tun a *Culvering*, and 2 Tun a *Saker*, with all things belonging thereunto, as Planks and Ropes.

SECT. XLVIII.

How many Horſes, Oxen, or Men will ſerve to draw a Piece *of* Ordnance.

FOr every hundred weight of Metal, one Man; ſo a Piece of 8000 Pound weight requires 80 Men, and as many more Men as the Carriage may be in hand weights; for every 00 weight of Metal, one Horſe, then 16 Horſes will draw a Cun of 8000 weight; but in the Winter 24; alſo 17 Yoke of Oxen is thought ſufficient to draw a Piece of 8000 weight, but in the Winter, they had need be one third part more.

Sect. XLIX.

How Gunners *may take a Plott of their* Garriſon, *and every object near it.*

He may by the *Compaſs* and *Ruler* directed in the ſeventh Chapter of *Surveying of Land*, take the Plott of his Garriſon, and every noted place or way within *Gun-ſhot*, and draw it into a Map, and have it in a readineſs, and need not be troubled to make Diſtances every time he hath an occaſion to make a Shot; but by his Scale and Map, may know if his *Gun* will reach any place thereabouts; and by the fourth Chap. of the General uſe of the *Canon* of *Logarithms* in Mr. *Gunter's* Works, learn the Practice of Fortifications, there it is put down for him at large.

OF ARTIFICIAL FIRE-WORKS, FOR Recreation, AND *SEA* and *LAND-SERVICE.*

CHAP. XIII.

SECT. I.

A Description of the Mortar-Piece, *and how to make one of Wood, and Paſt-Board (for a need,) Braſs and Iron ones being wanting.*

THe ſame Metal that makes the beſt ſort of *Braſs-Ordnance*, they make *Mortar-Pieces* with, and by theſe Meaſures; if the *Diam.* or Bore be 9 *Inches*, let the *Mortar* be one Foot and half in length, and let the Chamber in which you Load your *Piece* with *Powder* be 3 *Inches Diam.* and 4 and a half deep; the thickeſt of the Metal above the Touch-hole 3 *Inches*, and the upper part thereof 1 *Inch* $\frac{1}{2}$.

To make the Mortar-Piece *of Wood and Paſt-Board.*

Provide a Wooden-Ruler of ſuch bigneſs as you deſire to make the *Diameter* of the *Morter*, then greaſe your Ruler well, that the ſtuff may ſlip off that is put about him, which is Paſt-Boards and Canvas, and very well plyed with hot Glue; and after let it dry a little while on the Rowler, and another while off from the Rowler; and when this kind of Trunk is very dry, put it on the Ruler, and ſet it in a Lathe, and cut off both ends of the Trunk with a Chizel very even, then turn a Foot thereto with a ſhoulder to put the Trunk upon, and in the middle thereof make the Chamber for your *Powder*; if the *Piece* be 8 *Inches* in the Mouth, let the thickneſs of the Paſt-Board-Trunk be two *Inches* thick, and 18 *Inches* long, the Britch or Foot 10, the Shoulder 2 *Inches* long, and 2 high, that when the Trunk is put on this Shoulder, and joyned with the

Wood,

Wood, it may be juſt even with the ſame; the Bore into which you put your *Powder* muſt be two Inches high, and three deep, Plated with Copper, Lattin, (if it be poſſible) as alſo all the reſt of the Wood that goeth into the Trunk; when you have put the Trunk into the Britch of Wood, nail it round about the Shoulder, by making holes for the Nails, and then driving in the Nails upon that Wood, that you made to receive the Paſt-boards or Trunk; then cover both Wood and Trunk with good Belch-Cord and Glue again, and let it be well dryed, it will laſt a long time; and with ſuch you may Shoot Ballouns into the Air for Recreation.

Sect. II.

How to fit and prepare Granadoes *for the* Mortar-Piece.

THe Shot of great Mortar-Pieces are moſt commonly one tenth part lower than the Bore, becauſe of Cording them, to ſling into the Mouth of the Piece; and for fear of ſecret Cracks, which cannot be eaſily eſpyed, they are coated with Pitch, ſo that being fitted and prepared, they do but juſt fit the Bore.

How to make Fuſes.

Every Ball hath an hole left to put in a Fuſe, or piece of Wood, juſt like a Faucet for a Spiggot; this hole muſt be juſt one quarter of the *Diameter* of the wooden Fuſe, which Fuſe muſt be in length three quarters of the height of the Granadoe; make it taper, and then filled with compoſition, and driven gently into the Powder that is in the Ball, leaving a little of it without: the Compoſition of this Fuſe is made thus; take one Pound of Powder, four Ounces of Salt-Peter, and one of Brimſtone, firſt beaten to Powder, and ſifted in a Sieve ſeverally, theſe Ingredients being mixt together, your Compoſition is fit for uſe.

Sect. III.

How to make Granadoes *of Canvas for the* Mortar.

THe operation of theſe *Granadoes* made of Canvas is quite contrary to theſe already ſet down: theſe are only Fit to Fire a Town, they are not of ſo violent execution, as the precedent, yet altogether as coſtly in the making; for the making of them, fit a piece of Canvas upon a round Ball of Wood or Form, ſo big as you would have your Granadoe, then take this Compoſition following; four Pound of Salt-peter, two Pound of Gun powder duſt, and two Pound of Brimſtone; all theſe incorporated, and moiſtned with Oyl of Salt-peter; fill your Caſe with this Compound, and cover it with Cords, and pierce the Sack full of holes, and in every hole put an Iron Barrel, Charged like a Piſtol; theſe muſt be driven into the Sack unto the head, then let there be an hole about an Inch deep, which ſhall ſerve to Prime it with Powder-duſt, moiſten it with Oyl of Petrol; be ſure your Barrels have great Touch-holes, that the ruſt through time may not choak them, and they will be ready for ſervice many years.

Sect. IV.

How Granadoes *are to be Charged in a* Mortar, *and Fired.*

YOu muſt take great care in the Loading or Charging the Mortar, thus, firſt, weigh the Powder to a Drachm that you put into the Chamber, and after it put a good cloſe Wadd of Hay, or a Tampion of Wood, then cut a Turf off the Ground that may juſt fill the bottom of the hole or bore of the Mortar next the Wadd, your *Granadoe* being prepared, with a coat of Pitch and Cord, as before taught, ſling it into the Mouth of the *Mortar*; obſerve to have the Fuſe of the *Granadoe* in the middle of the Bore, then go to the Britch, thruſt up a Wire in the Touch-hole to make ſure, then Prime

Prime with the beſt drie Powder you have; for (believe me) this is a tickliſh ſort of Shooting; without care, your Life, and Mortar-Piece is now at ſtake; but we will give you very ſure directions how to give Fire.

Provide ſmall Fuſes, ſuch as we taught you to make before for the Shells, but leſs, about a quarter of an Inch bore, three quarters of an inch thickneſs, and eight Inches long, fill theſe with good Powder-duſt, moiſten it with Oyl of Salt-Peter but a little, and put it in with an Iron Rammer, try whether you like the time, they continue burning; if too ſlow, abate Oyl of Peter; if too faſt, add more to it.

Thus being prepared, the uſe is, (*viz.*) thruſt the Pick of your Linſtock in at one end of the Fuſe you mean to give Fire withal, bid one of your aſſiſtants come to one ſide of the Mouth of the Piece, and give Fire to your Fuſe, wherewith Fire the Fuſe in the Mortar, and then with great ſpeed give Fire to the Touch-hole; theſe Fuſes are very certain to give Fire, but Match doth ofttimes fail.

SECT. V.

How to make Hand-Granadoes *to be hove by Hand.*

THere is good uſe made of Hand-Granadoes in aſſaults, and Boarding of Ships, and there be two ſorts of them made; the firſt is ſhewed already, the ſecond is made by Sea-Gunners upon a Mould made with Twine. and covered over with Cartredge-Paper, and Muſquet-Bullets cut in two, put with Paſt and bits of Paper thick on the out-ſide; after you have doubled the Shells, Paſte on ſome at a time, and let it drie, and then ſome more, until he is quite full; then dip him in ſcalding Rozin, or Pitch, and hang him up, and he is for your uſe; but you muſt have the innermoſt end of the Twine. which muſt be left out at the ſmall hole for the Fuſe; and before you Pitch it, you are to wind it out, and ſtop the hole, and then Pitch it.

The Shells are made of Glaſs, or nelld Clay, or Paper.

To Load them, fill theſe ſmall Shells with Gun-Powder, then make a Fuſe of one Pound of Gun-Powder, ſix Ounces of Salt-Peter, and one of Char-cole; or if you will have them of leſs durance, you may take the Compoſition made for the Fuſes before ſpoken of for great Granadoes, knock the Fuſe up to the head within one quarter of an Inch, which is only to find it by in the night; ſtop well the reſt of the holes, if any Chinks are open, with ſoft Wax; then your firſt Shells muſt be coated with Pitch and Hurds, leſt it ſhould break with the fall; and be ſure when you have Fired the Fuſe, ſuddenly to caſt it out of your hand, and it will do good execution.

SECT. VI.

How to make Fiery-Arrows *or* Darts *like* Death Arrow-Heads.

MAke your Head of Iron, ſharp and bearded, to ſtick faſt; and to it have an Arrow or long ſhaft of Wood, and about the middle of that Head make faſt a Linnen Bag in form of an Egg, leaving open at the end a hole, that it may be filled with the Compoſition following; take one Pound of Peter, half a Pound of Gun-powder, and as much Brimſtone in Powder; all theſe Ingredients being mixt well, and mingled with Oyl of Petriol; with this fill the Bag round about the Arrow-head, then let all be bound about with Wire; and for Priming of theſe, dip Cotton-week into Gun-Powder wet with Water; and well dryed again before it is uſed, and let the Arrows or Shafts be ſo put into the Head, that when they be ſtuck in a Houſe or Ship-ſide, or any where elſe, the Man which endeavours to pull them out, may be deceived, and pull only the Shaft, and leave the Head to burn the Houſe, or Ship, or Mens Cloaths, or any thing elſe; if you throw or ſhoot it well, it will Fire whatſoever combuſtible ſtuff or matter ſhall be near it, as Sails, Timber, Pitch, Tarred places; and this will much aſſault Enemies in ſtorming a Work, or Boarding a Ship.

SECT.

Sect. VII.

How to make Fire-pots *of* Clay.

Fire-Pots, and Balls to throw out of Mens Hands, or with a *Baſcula*, may be made of Potters-Clay, with Ears baked, and to it hang lighted Matches, and throwing them, if it lighteth on a hard thing, it breaks, and the Matches Fire the Powder, and the half Bullets of Muſquets contrived upon them, as before, diſperſes, and doth much miſchief; their mixture is of Powder, Peter, Sulphur, and Sal-armoniack of each one Pound, and 4 Ounces of Camphire pounded, and Searced, and mixed well together with hot Pitch, Linſeed-Oyl, or Oyl of Peter; prove it firſt by burning it, if it be too ſlow, add more Powder, and if it be too quick, more Oyl, or Rozin, and then it is for your uſe.

Sect. VIII.

How to make Powder-Cheſts.

You muſt make them with 2 Boards to be nailed together, like the ridge of a Houſe, and one longer and broader to the bottom thereof; between the three Boards put a Cartredge, then make it up like a Sea-Cheſt, and fill it with Pibble-ſtones, Nails, Stubs of old Iron; then nail the Cover on, and the end to the Decks, in ſuch a place as you may Fire the Powder underneath through a hole made to put a Piſtol in.

Sect. IX.

How to make Artificial Fire-Works *for Recreation and Delight.*

VVE ſhall not deſcribe the Moulds in particular, being needleſs; for ſuch Men as are inquiſitive into theſe things, let them buy Mr. *Babington*, or *Bate*, or *Malthus*, or *Norton's* Fire-Works; here we will lay down ſuch Rules, as ſhall be as ſoon conceived without Figures, only a Rowler or Mould for to make the Paper upon; and that may ſerve for all the reſt, they being made in the ſame manner.

To mak good experienced Rockets our way, do thus; get a Form or Rowler to be turned in a Lathe, what thickneſs you pleaſe, and intend to make your Rockets, and let his length be 8 times the *Diameter*; if it be $\frac{1}{4}$ of an Inch in thickneſs, the length will be 6 Inches, put ſo many Rowls of Paper on this Form, until it is $\frac{1}{2}$ an Inch thick, or make it $\frac{1}{2}$ Inch the whole then Paſte the upper ſide to the reſt; then you muſt contract the Paper together an Inch from the Mouth, thus: dip an Inch of the Caſe in Water, the Formor in him, and with Twine, about $\frac{1}{4}$ of an Inch from the end gather it in; but let a Formor, or a thing near the bigneſs be put into his Mouth, while you draw it in with the Twine and choak it; you muſt remember to leave a ſmall hole to put in a Wire through the Compoſition half way the Rocket, as big as a Bodkin; then take out the Formor, and dry them, and they are for uſe at any time; the Figure following makes all plain; A is the Mouth of the Rocket, B ſo far the Bodkin muſt be thruſt up the middle; you muſt be provided with a ſmaller Bodkin, which when your Rocket is filled with the Compoſition, and tyed to the Rod, you muſt thruſt this Wire Bodkin in at the Mouth, ſtraight up to the midſt of the Rocket, having a care not to thruſt it more upon one ſide than the other.

SECT. X.

To make the Compoſition for Rockets *of any ſize.*

THe Reader may make uſe of theſe Rules, not upon truſt out of Authors, but found by Practice and Experience; and firſt for Rockets of 1 Ounce, you muſt uſe only Canon-Powder-duſt, being beaten in a Mortar, and finely Searſed; this makes him riſe very ſwift, making a great noiſe, but carries no Tail. Theſe of more Operations are made by putting one Ounce of Char-cole-duſt to 8 Ounces of Powder; this Compoſition will hold for Rockets of one, two, and three Ounces; but for theſe of four, take three Ounces of Char-cole-duſt, to one Pound of Canon-Powder-duſt, continuing that Rule, until you come to Rockets of 10 Ounces; and alſo for Rockets of a Pound, take one Pound of Powder-duſt, and four Ounces of Char-cole-duſt, and theſe are big enough for any Recreation or Delight.



To fill the Rockets *with this Compoſition.*

Hold the Mouth downwards where it was Choaked, and with a knife put in ſo much as you can of the Receipt provided for that ſize at one time, then with a Rammer fitted to the Caſe, and with a Mallet give three or four indifferent knocks, then put in more Compoſition until it be full, every time knocking the Rammer, as before, until the Compoſition come within one *Diameter* of the bore of the top; then put down a piece of Paſte-board, and knock it in hard, prick three or four little holes therein; then put fine Piſtol-Powder in almoſt to the top, and upon that another cap of Paper, upon which put a Piece of Leather, that it may be tyed on the top of the Rocket, and faſt Glued on; then get a ſtraight Twigg, and bind it upon the Rocket with good Twine; it muſt be no heavier, than being put upon your Finger an Inch and a half from the Mouth of the ſame, that it may juſt ballance the Rocket, then it is prepared for uſe.

To give Fire to one or two Rockets.

Set your Rockets Mouth upon the Edge of any piece of Timber, that ſtands ſo high from the ground, that the ſtick may ſtand perpendicular from it downwards or upon a ſide of a Wale or Carriage-wheel, or any dry place whatſoever; then lay a train of Powder that may come under the Mouth thereof; give Fire thereto, and you have done; but to Fire more Rockets than one, that as one deſcendeth, the other may aſcend by degrees: make this Compoſition following; of Roch-Peter eight Ounces, Quick-Brimſtone four Ounces, and fine Powder-duſt two Ounces, which lay in a Line, from one Rocket to another, they being placed ten Inches, or a Foot one from another; give Fire to this Compoſition, and you have your deſire, if you did prick the Rocket with the Wire, as directed; you ſhall ſee how gallant one will mount the Air, when the other is ſpent.

Sect. XI.

How to make flying Serpents *and* Rockets *that will run upon a Line, and return again.*

FOr this you must provide a small Rowling-Pin about one quarter of an Inch in thickness; upon which Roul seaven or eight thickness of Paper; fill them four Inches with Powder-dust, sometimes putting between the filling a little of the Composition for Rockets of ten Ounces, and at the end of four Inches choak him; fill two Inches more with Pistol-Powder, then choak the end up, and at the other end put in a little of the mixture for Stars, which follows, and choak between them and the Composition, and it is fit for use; but divers of those with the Starry end downwards upon the head of a Rocket and Powder-train to blow them out, when the Rocket is spent, they will first appear like so many Stars; when the Stars are spent, taking hold of the Powder-dust, they will run riggling to and fro like Serpents; and when that Composition is spent, they will end with every one a Report, which will give great content to the beholder.

I did omit to speak of Runners in its proper place in the last Section, for that is the Composition, which you must make them of, very carefully whether they be, double or single, or those that carry Dragons, Men, or Ships, or other Shapes in motion, least they shame their Master; the Line must therefore be fine, even, and strong, and being rubbed over with soft Sope to make it slippery, and not easily to take Fire; Those that turn Wheels, may have a further addition of Roch-Peter in their Receipts to add pleasure and life to the beholders; You must have a piece of Cane as long as the Rocket, and bind to the Rockets, and so that ones Head may be to the others Vent, that when one hath carryed the Cane on the Line to the end thereof, the other may Fire, and bring him back again to the Tower or place where it was fired; these Figures are made with strong Paper or Parchment, and with Lattin, and Wire, and Twine, until they be brought into these Shapes, and then painted like Ships, or Dragons, or like the thing it carries with it.

Sect. XII.

How to make Fire-Wheels, *or as some call them* Girondles.

FIrst be provided with Spinning-Wheels or the like, made easy to run round upon its *Axis*, Horizontal, or Vertically; and put Flags on the top of the middle, to set out the Wheel; bind Rockets to the Wheel, and Crackers betwixt each Rocket, with the Mouth of one towards the Tail of the other, thus continued, until you have fitted the Wheel quite round; which done, cover them with Paper pasted over, and coloured handsomly to set it out, that one taking Fire, they may not Fire all, and daub Soap upon them quite round, leaving the Mouth of one of them open, to give Fire thereto; the first Rocket being burned, will set Fire to the rest one after another, keeping the Wheel in a continual motion, until they be all spent; you may bind Fire-Lances to these Wheels, either upright, or near over athwart, which will make to appear diversity of Fire-Circles; you must take care to place your Wheels called *Girondles* at convenient distance from other Fire-Works, least they should make a confusion, and spoil all the Work.

SECT. XIII.

How to make divers Compoſitions for Starrs.

FOr Starrs of a Blew colour mixed with Red, the Compoſition is of Powder-meal'd eight Ounces, Salt-Peter four, Quick Brimſtone twelve Ounces, Meal all theſe very fine, and mix them together with two Ounces of *Aqua Vitæ*, and half an Ounce of Oyl of Spike; which let it be very dry before you uſe it.

Another Compoſition which will make White and beautiful Fire; take Powder eight, Salt-Peter 24, quick Brimſtone two, Camphire one Ounce, Meal theſe Ingredients, and Incorporate them; make the Camphire with dipping your Peſtil into a little Oyl of Almonds, and it will Meal preſently, and keep it cloſe from the Air, or elſe it will become of no uſe.

Another White-Fire which laſteth long, take Powder four, Salt-Peter 16, Brimſtone eight, Camyhire one, Oyl of Peter two Ounces, Meal theſe that are to be Mealed; and mix them according to the former directions.

SECT. XIV.

How to make and uſe the Starrs.

TAke little ſquare pieces of Brown Paper, which fill with either of the foreſaid Compoſitions which you like beſt, fold it down, rowling it til you make it round, about the bigneſs of a Nut or bigger, according to the ſize of your Rocket that you intend them for, Prime them with drawing through them Cotton-Week, and they are prepared to make faſt to the Wheels: you may alſo make them thus; you muſt have a Rowler which muſt be as big as an ordinary Arrow, which ſhall be to Rowl a length of Paper about, and Paſte it round, and dry it well, fill it with a Thimble, and thruſt it down with a Rowler, and then cut it in ſhort Pieces about half an Inch long; then you muſt have in readineſs either hot Glue, or Size mingled with red Lead, dip therein one end of your ſhort Pieces, leaſt they take Fire at both ends together, beſides, it will not ſo eaſily blow out; theſe being thus done, ſet them to dry until you uſe them, and in the top of the Rocket, whereas in the 10 Section you were to fill it with Piſtol-Powder, now you muſt put none, but a very little, and that is to blow one of the bits of Starrs out, which muſt ſtand in the room of the Powder, and on the top of that another Tire, with ſtrewing a little Powder and duſt; and in like manner another, to a third or fourth, putting a little ſmall corned Powder between them, until you come unto the top of the Rocket-caſe, there put a Paper over the Head of it, and tie it cloſe about the top, that none of the Powder come from between the Starrs; the Cotton-Week is ſuch as the Chaundlers uſe doubled 6 or 7 times, dipped in Salt-Peter Water, or *Aqua Vitæ*, wherein ſome Camphire hath been diſſolved, or for want of either, in fair Water, cut it in divers pieces, Rowled in Mealed Powder dryed in the Sun, and it is done.

SECT. XV.

How to repreſent divers ſorts of Figures *in the Air with* Rockets.

VVHen you have divers Rockets to make for a great Fire-Work, let one be with a Report, another with Starrs, another with Golden Hair or Rain, one with Silver Hair or Rain, which it ſeems to be when you are right under; and upon the Head of another Rocket place the Serpents, and they will make moſt delightful ſport.

Sect. XVI.

How to make Silver and Golden Rain, *and how to uſe them.*

You muſt provide ſtore of Gooſe-Quills, which being provided, you muſt cut them off ſo far as they are hollow; the Compoſition to fill them is, two Ounces of Cole-duſt, and one Pound of Powder well mixed; having filled many of theſe Quills, you ſhall place them in the ſame place as I told you to put the Powder and Stars, putting a little Piſtol-Powder to blow them out, as you did the Stars, and fill the top of the Caſe as full of them as you can, with the open end downwards; ſo ſoon as the Rocket is ſpent, there will appear a Golden Shower, or Rain; or with the Compoſition for White-Stars filled in the Quills, will make a Shower of Silver Rain.

Sect. XVII.

How to make Fire-Lances.

Make them thus; firſt, you muſt make Cartredges, or Caſes juſt like the Caſes for Rockets, only thoſe for a need may be made with Paſt-Board, and Glued, as they are formed round, but the former is better; let them be filled with the drie Compoſition for Stars in the 13th Section; Prime them with wet Gun-Powder, the lower end of the Caſe is ſtopped with a piece of Wood, to the end they may be nailed and ſtirred when and where they ſhall be uſed, the Wood being about three Fingers breadth long out of the Caſe or Cartredge, or as long as you will.

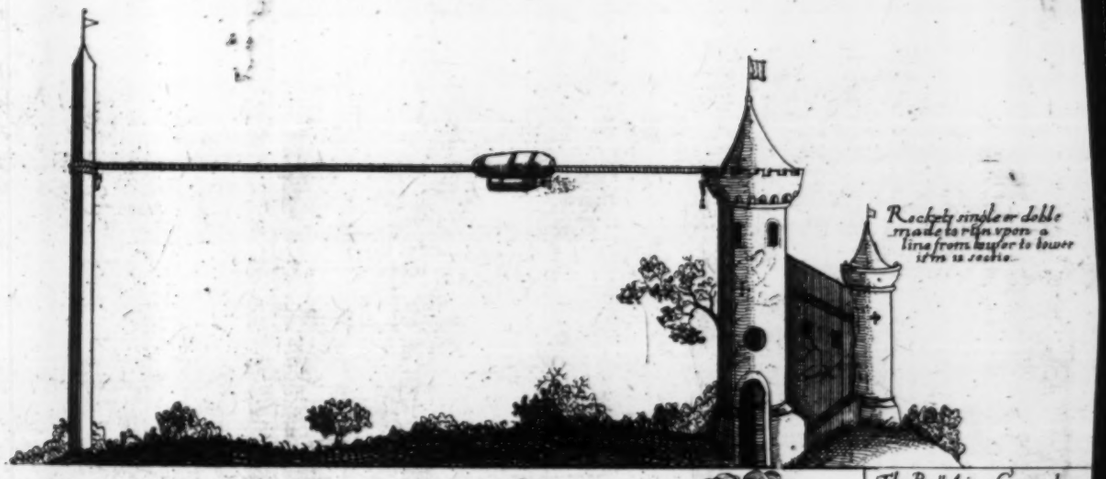
Sect. XVIII.

The manner how to make Balloons *for the* Mortar-Piece.

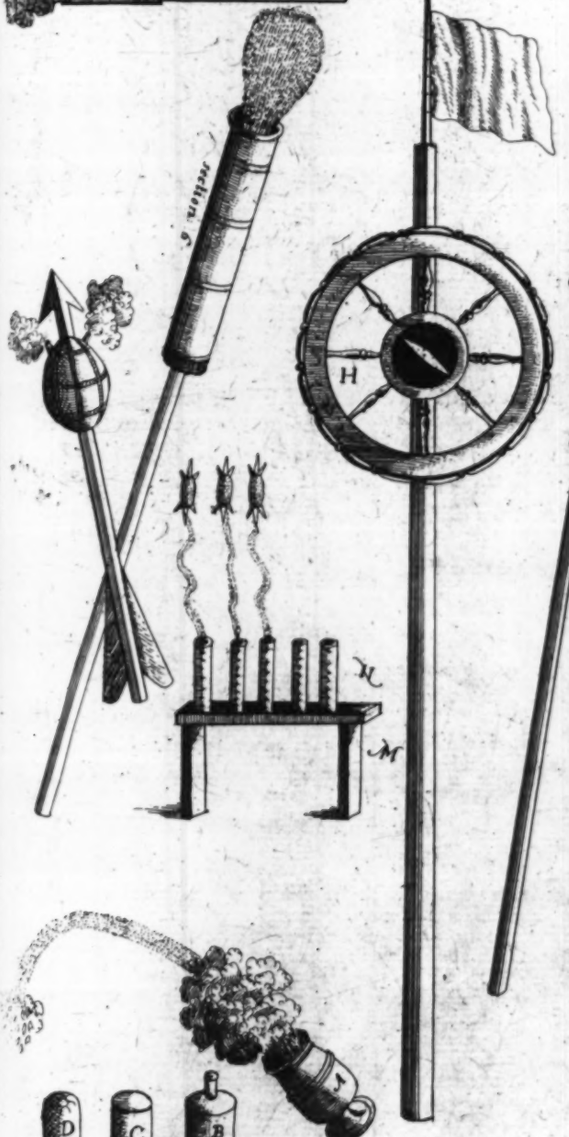
You muſt have a Formor or Ruler twice the length of the Diameter and of the bigneſs, as you will have the inſide of your Balloon, and upon that Formor put ſo many Paſt-Boards, as you ſhall think ſufficient for ſtrength, then Paſte or Glue them well together, and choak him at the end with a String, leaving a ſmall hole for a Port-Fire, which muſt be made juſt like a Rocket but no holes in it as the Rocket hath, and of ſuch length as is fit: now to fill the Balloons, place all your Serpents within it together, with Stars, Rockets, and Crackers, leave very little room within the Caſe, or Cartredge; and being filled, put in as much Powder-duſt as you can, that it may run every where through the Chinks between the Serpents, Rockets, and Stars, that they may all Fire, and that the ſaid Powder-duſt may break the Balloon; theſe things thus done, choak up the other end cloſe, and Charge it in the Mortar, as we have taught you to do the Canvas Granadoe in the fourth Section, and you may ſhoot it when you pleaſe, and you will make moſt excellent delight to the Spectators, and credit to your ſelf; for this is part of the way of Mr. *Malthus*'s Fire-Works, which were the beſt that ever I practiſed.

Sect.





section 8.









The Ball A is a Granado, cooled armed and lapdog sect: 4.

Fire Pots of Clay wch weare and marked is B section. 7.

Balls to fire and stick is D made of ſ^e same stuffe a 7 section

Fire Arrowes or darts sec ſ^e 6 is E

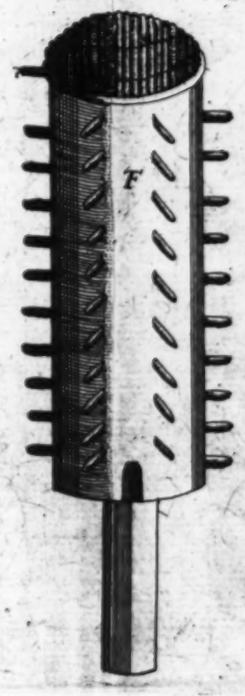
F G is a cillinder Granad of turned timber to shoote fliers section the 10.

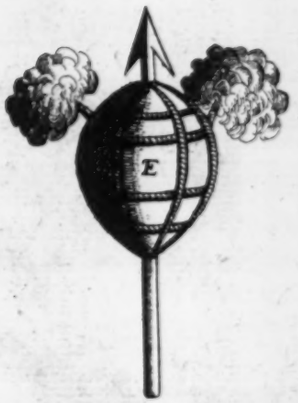
Uertuall wheele is H sec 12 by wch you may und ſ^e stand ſ^e form of horiz dall wheeles or any oth sort:

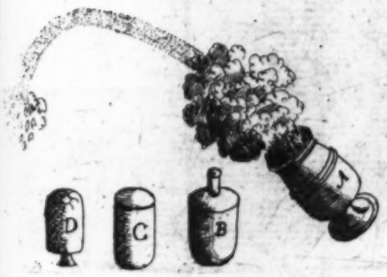
A B C D are the mou Piece mould and Ball section 18.

And M N is ſ^e wooden Morters or Chambers a in section 18









Booke. V. p. 90. 91.

SECT. XIX.

A moſt precious Unguent *for any Burning.*

DIvers Men in the Practice of Fire-Works one time or other chance to be burned, or blown in the Face by Powder; here you have Mr. *Malthus*'s Salves, which is known by often Experience to be very good, and will fully cure you.

The *SALVES.*

Take freſh Hogs-Greaſe, or Lard, as much as you pleaſe, and boyl, and take off the Scum, until there ariſe no more Scum; then ſet the Lard three or four nights abroad, after which it muſt be waſhed in running Water to take away the Saltiſh nature, and to make it White; then melt it, and keep it for your uſe.

Otherwiſe,

The White of an Egg, and freſh Butter being mingled together, and well beaten into an Oyntment, is excellent good.

SECT. XX.

Another Salve *moſt Excellent.*

TAke a Stone of Quick Lime, and let it be diſſolved in clear Water, and when the water is ſettled, pour it out gently from the Lime through a Linnen cloath, then put as much Saller Oyl, as you have Water together, and beat it all to an Oyl; you may keep it for ſuch uſes, and you have a moſt Sovereign Cure for all manner of Burning whatſoever.

The End of the Fifth Book.

TO

TO

Cap. *SAMUEL STURMY*,

THE

AUTHOR,

For his Work and Worth.

SInce 'mongſt all Nations *War* it ſelf doth ſhew,
It Man behooves *Wars* Weapons for to know.
Who here may learn the *Gunner*'s aiming *Arts*,
Which thy free Induſtry to all imparts.
The fitteſt Subject now it is by far,
At theſe times when ſuch Rumors are of *War*.
And fills the Ears, and courages awake;
Go on then, and to thee this credit take, (write,
That he that Reads theſe things which thou doſt
May know a *Gunner*'s part, though he never Fight.
And know *Wars* chiefeſt Engines uſe, and ſtrength,
In *Bar*, *Cylinder*, *Axis*, and in *Length*;
In *Touch-hole*, *Carriage*, *Wadd*, in *Shot* and *Charge*;
Of *Fire-Works*; in brief, Thou giv'ſt in Charge
French, *Spaniſh*, *Dutch*, *Italian*, Vail your Caps
To the Author's skill in *Mars* his Thunder-Claps.

Cap. *JOHN VINCENT.*

THE

THE MARINER'S MAGAZINE;

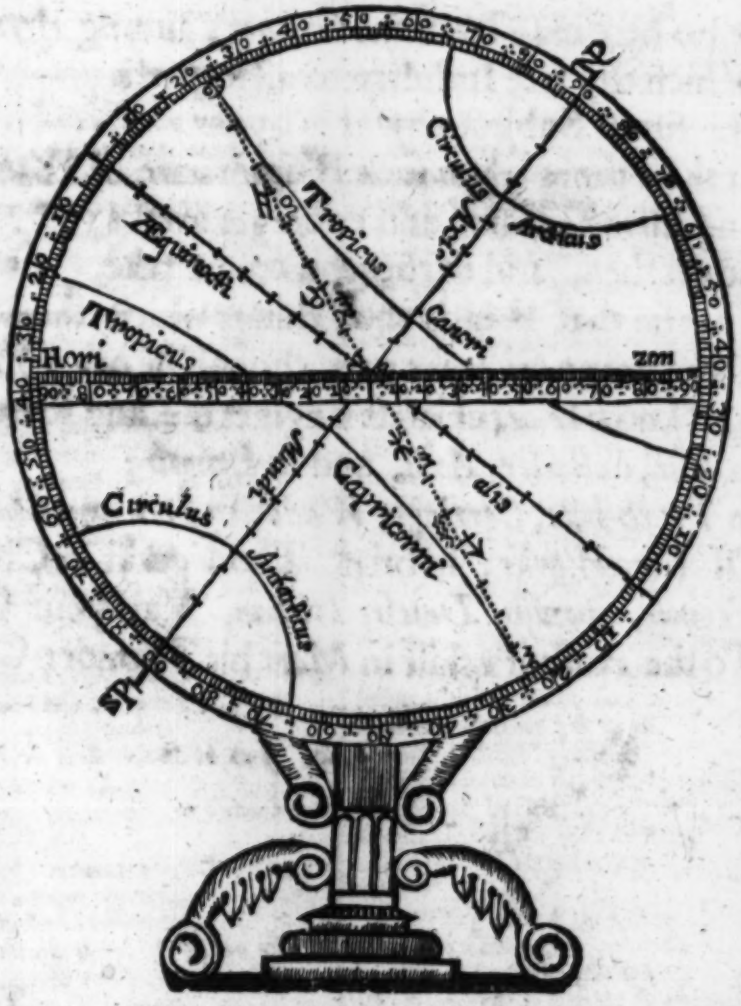
OR,

STURMY'S Mathematical and Practical ARTS.

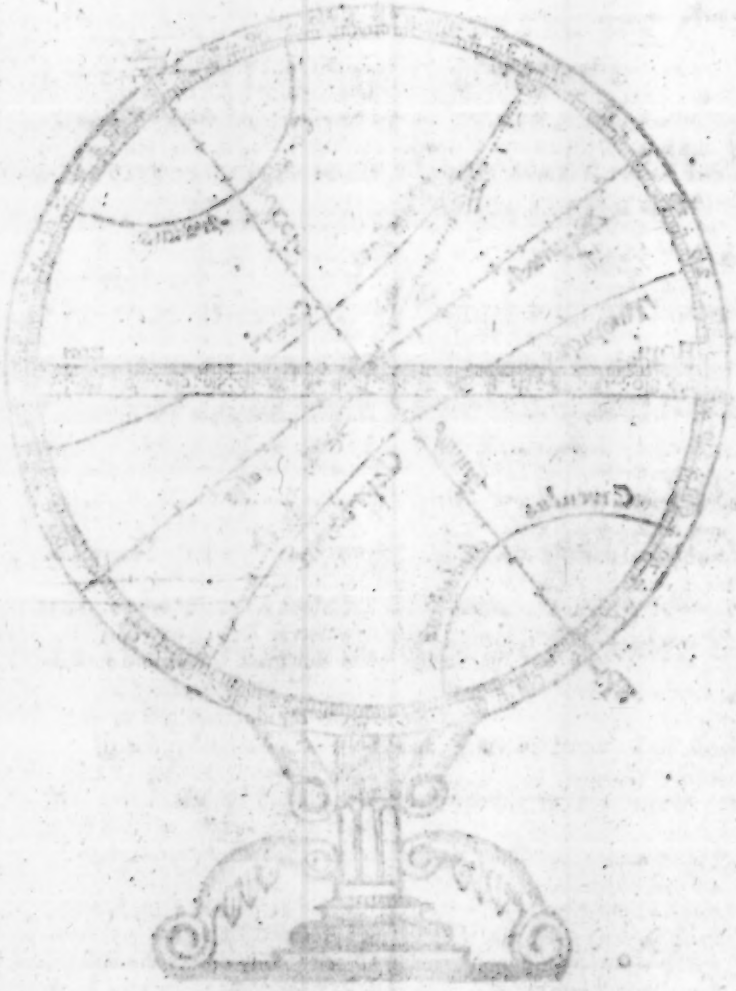
The Sixth Book.

Wherein is Contained,

The Definitions of the *Circles* of the *Sphere*; With the manner how to Reſolve all the moſt neceſſary Propoſitions thereunto belonging, by a *Line* of *Chords* and *Signs*, As alſo, by *Chords* and *Tangents*, and half *Tangents*; and likewiſe by *Calculation* of the *Tables* of *Artificial Signs* and *Tangents*, and all uſual *Aſtronomical* Propoſitions appertaining to the firſt Motions, being all of extraordinary Uſe; whereof few of them have yet been Treated ſo plain in the *Engliſh Tongue*.



Felices anima quibus hæc cognoſcere primum
Inque domos Superas ſcandere cura fuit.



THE

Denomination of Eight and Forty Conſtellations of the Fixed STARS;

OR,

The Rudiments of ASTRONOMY,

Put into plain RHYTHMES.

THe Army of the Starry Sky,
Declares the Glory of God moſt high,
Seen and perceived of all Nations,
In Eight and Forty Conſtellations.
Firſt, near unto the Northern Pole,
The Dragon and two Bears do role,
Whoſe hinder parts and Tails contain
The leſſer and the greater Wain.
The Hare, the Bear-ward, and the Crown;
And then comes *Hercules* kneeling down;
And next below a place doth take,
Great *Serpentarius* with his Snake.
Under the Harp of *Orpheus*,
The Eagle, and *Antinous*,
The Silver Swan her wings doth ſpread
Above the Dart and Dolphin's head;
Then *Pegaſus* comes on amain,
Andromida follows in her Chain;
The Triangle below her ſtands,
And at her Feet in *Perſeus*'s hands,
The *Gorgon*'s head above are ſeen;
Her Parents *Cepheus*, with his Queen
Caſſiope, not far below,
Heniochus his Goat doth ſhow;
On his left Shoulder, in his Hand
He doth the ſtormy Kids command.
Here in the *zodiack* begins (Twins (♊,)
The Ram (♈,) the Bull (♉,) the loving
The Crab (♋,) the Lion (♌,) and
(Virgin (♍) tender;
The Ballance (♎,) Scorpion (♏,) and
Bow-bender (♐,)
Goat (♑,) Water-man (♒,) then Fiſhes
twain (♓,)
Shall bring you round to the Ram(♈)again.
Fifteen Images appear
In the Southern Hemiſphere,
The monſtrous Whale above the reſt,
Eridanus ſcarce wets his Breaſt,
Over the Hare *Orion* bright,
Sparkles in a cold Winters Night;
Then comes the great Dog, at whoſe Tail,
The famous *Argo* ſpreads her Sail:
Above the little Dog doth flame,
For whom the Latins had no Name;
Long *Hydra* on her Tail alow,
Carries the Pitcher and the Crow;
The Centaur holds the Wolf by th' heel,
The Altar, and *Ixion*'s Wheel,
Are never ſeen of us; but here
The Southern Fiſh brings up the rear.

The *Planets*.

Under thoſe Fixed *Stars* above,
Seven *Planets* in their Orbs do move;
The higheſt is *Saturn*, thirty year
He ſpends in compaſſing his Sphere;
Twelve *Jupiter*, and *Mars* in twain,
Sets forward, and comes round again.
Then in one year the Sun diſplays
Three hundred ſixty and five days;
And near a Quarter, which in Four
Encompaſſings, makes one Day more.
Between the Sun and us, there fly
Fair *Venus*, and ſwift *Mercury*;
Theſe always near the Sun we find,
Not far before, nor far behind.
The Moon is loweſt, who in ſeaven
And twenty Days goes round the Heaven;
And about two Days more doth run,
Before ſhe overtakes the Sun.
So twenty nine and half in all,
Do make a Month Synonidal.
Theſe *Planets* make their courſe to th' Eaſt,
Though they be faſter hurled Weſt;
And ſix Degrees the reſt may ſtray,
Beſides the Suns *Ecliptick* way.

Job 9. *v.* 31. Canſt thou bind the ſweet Influence of the *Pleiades*, or looſe the Bonds of *Orion*? *ver.* 32. Canſt thou bring forth the *Mazzaroth* in his ſeaſon, or canſt thou guide *Arcturus* with his Sons?

The Circles of the Sphere.

Six greater Circles mark you ſhall,
Which equally divides this Ball;
Juſt in the midſt in between the Poles,
From Eaſt to Weſt the *Equator* Roles.

The *Ecliptick* cuts him, and doth ſlide
Twenty three and half Degrees aſide.
Horizon even with the ground,
From Stars below our ſight doth bound.
Meridian ſtraight upright doth riſe,
Parting the Eaſt and Weſtern Skies.
Two Colures through the Poles do run,
Quartring the Circle of the Sun;
One where the Spring and Fall begin;
Th'other where longeſt Days come in:
Four leſſer Circles mark them well,
Are to th' *Equator* Parallel.
Two *Tropicks* bound the Sun's high way,
Shewing the long'ſt and ſhorteſt Day.
The *Arctick* Circle cuts the Bears,
Th' *Antarctick* oppoſite appears.
Meridians half twenty four,
For Hours, and for Degrees Nine ſcore;
Through both the *Poles* o'th' World do paſs
And the *Equinoctial* down-right croſs;
And Nineſcore Parallels have that Line,
By which Stars North and South decline.
The *Ecliptick* hath his Longitudes,
And Parallels of Latitudes
For Stars; But in *Geography*,
The Towns beſides the *Equator* lie.
Over our Head, and under Feet,
The Nineſcore *Azimuths* do meet;
And here as many Parallels,
Of Altitude Horizontels.
Longitudes and Meridians all,
And *Azimuths* great, Circles call.
But all the Parallels in Heaven,
Being leſſer cut, the Globe uneven.
Degrees three hundred and threeſcore
Hath every Circle, and no more.

***The Heavens declare the Glory of God, and the Firmament ſheweth his handy-work*, Pſal. 19.**

***When I conſider the Heavens the work of thy Fingers, the Moon, and the Stars which thou haſt ordained, what is Man, that thou art mindful of him? or the Son of Man, that thou viſiteſt him?* Pſal. 8.**

STURMY'S
MATHEMATICAL and PRACTICAL
ARTS.

The Sixth Book.

Wherein is contained a Definition of the Circles *of the* Sphere, *with the manner how to Reſolve all the moſt neceſſary* Propoſitions *thereunto belonging, by a* Line *of* Chords *and* Signs, *or by* Chords *and* Tangents; *as alſo by Calculation by* Tables.

CHAP. I.



IN the former Books are contained ſuch Problems Geometrically, as are moſt neceſſary for every profeſſed ingenious Artiſt to underſtand and Practice; Now to the end the Practitioner may Elevate his Thoughts to the contemplation of thoſe Glorious Bodies, the Sun, Moon, and Stars; I ſhall here in this place give a brief Survey of the firſt Rudiments of *Aſtronomy*, for the help of young Practitioners and Mariners, for whom chiefly I take theſe pains; I ſhall give a brief and ſuccinct Explanation of the ſeveral *Circles* of the *Sphere*, better than we could in the foregoing *RHYTHMES* to be underſtood, and then ſhew how to reſolve the moſt uſual and common Problems thereof; and after the Art of *Dialling* Geometrically and Inſtrumentally, and by Calculation, as promiſed.

1. This is to be underſtood, that Aſtronomers do imagine 10 principal Points, and 10 Circles to be in the hollow inſide of the firſt Moveable Sphere, which are commonly drawn upon any Globe or Sphere, beſides divers other Circles which are not delineated, but only apprehended in the Fancy.

The Points are the two Poles of the World, the two Poles of the *Zodiack*, the two *Equinoctial* Points, the two *Solstitial* Points, and the *Zenith* and *Nadir*.

2. The *Poles* of the World are two Points, which are directly opposite to one another, about which the whole frame of Heaven moveth from the *East* into the *West*, whereof that which is seen on the *North*-side the *Equinoctial*, is called the *Arctick-Pole*.

3. And the other directly opposite to the former is called the *Antarctick*, or *South-Pole*, and can be seen only on the *South*-side of the *Equator*; a right Line imagined to be drawn from the one Pole to the other, is called the *Axis* or *Axle-tree* of the World.

4. All other Lines drawn through the Centre of the *Sphere*, and limited on each side of the surface of the Sphere, is a Diameter, but not an *Axis*, unless the Sphere move round about it.

5. The Poles of the *Zodiack* are two Points directly opposite to each other, distant from the *North* and *South* Pole 23 *degr.* 31 *min.* and are Diametrically opposite, on which the Heavens move, from the *West* into the *East*.

6. The *Equinoctial* Points are in the beginning of *Aries* and *Libra*, to which Points the Sun cometh the 11 of *March*, and 13 of *September*, and makes the Days and Nights of equal Length in all places in the World.

7. The Point of the Summer *Solstice*, is the beginning of *Cancer*, which the Sun cometh unto about the 12 of *June*, and longest day, to the Inhabitants on the *North* part of the World, and the shortest day to the Inhabitants of the *South*.

8. And the Point of the Winter *Solstice*, is the beginning of *Capricorn*, to which the Sun cometh the 11 of *December*, and maketh the shortest Days of the Year to the Inhabitants of the *North Hemisphere*, and the longest to the Inhabitants on the *South*-side the *Equinoctial*.

9. The *Vertical* Point, or *Zenith*, is the Point directly over-head, and is the Centre or Pole of the *Horizon*, 90 *degr.* every way from the *Horizon*.

10. The *Nadir* is the opposite Point under our Feet.

Circles of the Sphere.

The Ten Circles are as followeth; The *Equinoctial*, or likewise called the *Equator*, which is the chief Circle in the *Sphere*, dividing the Heavens in the middle between the two Poles; the two Points of *Aries* and *Libra*, cut this Circle in opposite Points, and make the Days and Nights of equal length over all the World.

2. The *Meridian* is a great Circle passing through the Poles of the World, and the *Zenith* of the Place; the Sun when he comes to this *Meridian*, it is Noon; the number of *Meridians* is as many as can be imagined *Vertical* Points from the *West* to the *East*, whereof the *Cosmographers* have described, 180.

3. The *Horizon* is distinguished by the names of Rational, or Sensible; the first is a great Circle every where Equidistant from the *Zenith*, and divides the superior or upper *Hemisphere*, from the lower, and by chance are distinguished by the names of Right, Oblique, and *Parallel-Horizon*.

A *Right-Horizon* have the Inhabitants under the *Equator*, who have the *Horizon* passing through the Poles of the World, and cuts the *Equator* at Right-Angles.

An *Oblique-Horizon* is such an one as cuts the *Equinoctial Oblique*, or *aslope*, or hath any *degr.* of Latitude from the *Equator*.

A *Parallel-Horizon* is one that hath the Poles for the *Zenith* and *Nadir*, and the Equinoctial for the *Horizon*.

The *Senſible-Horizon* is a Circle that divideth the part of the Heavens, which we ſee, from the part we ſee not, called a *Finitor*.

4. The *Zodiack* is a great Circle, that divides the *Equator* into two equal parts; the Points of Interſection are *Aries* and *Libra*, the one half declining toward the *North*, the other to the *South* 23 *degr.* 31 *min.* his ordinary breadth is 12 *degrees*; but later Writers make it 14 or 16 *degrees* by reaſon of the wandring of *Mars* and *Venus*.

In the middle thereof is a Line called the *Ecliptick*, from which the Latitude of the Planets are numbred both Northward and Southward; the Circumference of this Circle containeth 360 *degr.* which is divided into 12 equal Parts called Signs, every one repreſenting ſome living Creature, either in Shape or Property, as you read in the Denominations; and alſo every Sign containeth 30 *degr.* and every *degree* containeth 60 *min.* and every *min.* 60 *ſeconds*, and every *ſecond* 60 *thirds*.

The Names and Characters of the 12 Signs.

♈	♉	♊	♋	♌	♍
Aries.	*Taurus.*	*Gemini.*	*Cancer.*	*Leo.*	*Virgo.*
♎	♏	♐	♑	♒	♓
Libra.	*Scorpio.*	*Sagitarius.*	*Capricornus.*	*Aquarius.*	*Piſces.*

5. The Six uppermoſt are the Northern, and Six undermoſt the Southern Signs.

Of the Colures.

6. Theſe are two great Circles, or two Meridians paſſing through the Poles of the World, croſſing one the other at right Angles, and dividing the *Equinoctial* and the *Zodiack* into four equal parts, making thereby the four Seaſons of the Year.

7. The *Solſtitial Colure* is as before, a great Circle drawn through the Poles of the World, the Poles of the *Zodiack*, and the *Solſtitial* Points of *Cancer* and *Capricorn*, ſhewing the beginning of Summer and Winter.

8. The *Equinoctial Colure*, is a Circle paſſing by the Poles of the World through both the *Equinoctial* Points of *Aries* and *Libra*, ſhewing the beginning of the Spring and Autumn, when Days and Nights are equal.

9. The *Tropick* of *Cancer* is a leſſer Circle of the *Sphere*, equally diſtant from the *Equinoctial* to the Northward 23 *degr.* 31 *min.* 30 *ſeconds*, wherein when the Sun is, he is entring *Cancer*, and making his greateſt Northern Declination.

10. The *Tropick* of *Capricorn* is alſo a leſſer Circle, equally diſtant from the *Equinoctial* Southward 23 *deg.* 31 *min.* 30 *ſeconds*, to which when the Sun cometh, which is the 10th of *December*, maketh his greateſt Southern Declination.

11. Of the two *Pole Circles.*

Theſe are two leſſer Circles, diſtant ſo much from the Poles of the World, as the Tropick of *Cancer* and *Capricornus* is from the *Equinoctial* 23 *degr.* 30 *min.* which are the Pole Points of the *Zodiack*, which moving round the Poles of the World, deſcribe by their motion the ſaid two Circles; that about the North-Pole is the *Arctick* Circle, and that about the South the *Antarctick* Circle.

12. The firſt Six are called great Circles, and the other Four leſſer Circles; by the Centre of a Circle is meant a Point or Prick in the middle of a Circle, from whence all Lines drawn to the Circumference are equal, and are known by the names of *Radius*.

13. That

13. That is ſaid to be a great Circle, which hath the ſame Centre as the Sphere, and Divides it into two equal halfs, called *Hemiſpheres*; and that is a leſſer Circle, which hath a different Centre from the Centre of the Sphere, and Divides the Sphere into two unequal Portions or Segments.

14. Of other Circles imagined but not deſcribed in a material *Sphere* or *Globe*. Such are the *Azimuths*, *Almicanters*, *Parallels* of *Latitude* and *Declination*.

Azimuth or *Vertical Circles* paſs through the *Zenith*, and Interſect the *Horizon* with right Angles; wherein the diſtance of the Sun or Stars from any part of the *Meridian* are accounted, which are called *Azimuth*, and the *Eaſt* and *Weſt* is called the Prime *Vertical Azimuth*.

15. The Sun or any Star having Elevation or Depreſſion above or below the *Horizon*, are then properly ſaid to have *Azimuths*; but if they be in the *Horizon*, either riſing or ſetting, the Arch of the *Horizon* between the Centre of the Sun or Star, and the true Points of *Eaſt* and *Weſt*, is called *Amplitude*.

16. Circles of *Altitude* called *Almicanters*, are Circles Parallel to the *Horizon*, and Interſect the *Vertical Circles* with right Angles, which are greateſt in the *Horizon*, and meet together in the *zenith* of the place, in which Circles the Altitude of the Sun, Moon, or Stars above the *Horizon* are accounted, which is the Arch of an *Azimuth*, contained betwixt the *Almicanters*, which paſſeth through the Centre of the Sun, Moon, or Stars, and the *Horizon*.

17. *Parallels* of Declinations are leſſer Circles, all Parallel to the *Equinoctial*, and may be imagined to paſs through every *degree* and part of the *Meridian*, and are deſcribed upon the Poles of the World; in like manner, the Declination of the Sun or Star is meaſured by the Arch of the *Meridian* between the Sun and Star, and the *Equinoctial*.

18. *Parallels* of *Latitude* in the Heavens, are leſſer Circles deſcribed upon the Poles of the *zodiack* or *Ecliptick*, and ſerve to define the Latitude of a Star, which is the Arch of a Circle contained betwixt the Centre of any Star or Planet, and the *Ecliptick* Line, making right Angles therewith and counted toward the *North* or *South* Poles of the *Ecliptick*, the Sun never paſſeth from under the *Ecliptick-Line*, is ſaid therefore to have no Latitude.

19. *Longitude* of the Sun or Stars is meaſured by the Arch of the *Ecliptick*, comprehended between the Point of *Aries*, and a ſuppoſed great Circle paſſing from the Poles of the *Ecliptick*, and the Sun or Stars Centre, and accounted according to the order and ſucceſſion of the Signs.

20. Longitude on the Earth, is an Arch of the *Equinoctial* contained between any aſſigned *Meridian* where it begins, and the *Meridian* of any other place, but accounted Eaſtward from the firſt place, as the Right-Aſcention; but in my Tables it is counted *Eaſt* and *Weſt* from the *Meridian* of the Lands-end terminating at 180 *degrees*.

21. *Right-Aſcention* is an Arch of the *Equinoctial* accounted from the beginning of *Aries*, which cometh to the *Meridian* with the Sun, Moon, or Stars, or any portion of the *Ecliptick*; and by it there are Tables made for the Sun, Moon, and Stars to know the time of their coming to the *Meridian*, as by the help of the hour of the Star, the true time of the Night.

22. *Oblique Aſcention*, is an Arch of the *Equinoctial* between the beginning of *Aries* and that part of the *Equinoctial*, that riſeth with the Centre of the Sun or Star, and any portion of the *Ecliptick* in any *Oblique-Sphere*.

23. *Aſcentional-difference* is the Arch of Difference between the *Right-Aſcention*, and the *Oblique-Aſcention*, and thereby is meaſured the time of the Sun or Stars before, and after Six.

24. *Elevation* of the *Pole* is the Height thereof above the *Horizon*, which is equal to the diſtance between the *zenith*, and the *Equinoctial*, whoſe Complement is equal to the diſtance of the *zenith* from the *North* or *South* Pole, or the Elevation of the *Equator* above the *Horizon*; theſe Circles I have inſerted, to the end they may be perfectly known, for without them, the Reader cannot well underſtand the following Problems of the *Sphere* that are depending thereon.

CHAP. II.

Chap. II.

The Projection of the Sphere *in* Plano, *repreſented by the* Analemma, *and the* Points *and* Circles *before deſcribed.*

THe Sphere may be Projected in *Plano* in ſtraight Lines, as in the *Analemma*, if the *Semi-diameters* of the Circles given, be Divided in ſuch ſort as the Line of Signs in the Fundamental Diagram of the Scale.

This Scheme is fitted for the Latitude of *Briſtol* 51 *degr.* 28 *min.* and repreſents the Points and Circles of the Sphere before deſcribed.

Take with your *Compaſſes* the Chord of 60 *degr.* and upon the Centre C deſcribe the Circle HZON (2.) Draw the *Diameter* HCO which repreſents the *Horizon*; and at Right-Angles thereunto, croſs it with another *Diameter* ZCN.

Then with the Latitude of the place, prick off 51 *degr.* 28 *min.* from O to N, and from H to S; and of the ſame Line of Chords, take the Complement of the Latitude 38 *degr.* 32 *min.* and prick off from HÆ, and from O to Q, and draw NSC and ÆCQ.

Then take the Suns Declination 23 *degr.* 31 *min.* and prick off from Æ to G and T, and with the like Chord do the ſame from N to Y and *g*, for the Polar Circle; and the like do from Q to D and P, and from S to X and ♄; and through theſe Points draw Parallels to the *Equator* Y*g*, and TSD, and G*h*: P, and X♄.

And through the Centre draw the *Ecliptick-Line* TGP; and draw RS Parallel to the *Horizon* HCO, which is the Parallel of Altitude of the Hour of Six; and at any other diſtance, draw Parallels of Altitude E*If*.

(1.) Thus are the Points before defined, repreſented in this Diagram; N is the North-Pole-*Arctick*, S the South-Pole-*Antarctick*; *g* the North, X the South-Pole of the *Ecliptick*; C both the Equinoctial-Points of *Aries* and *Libra*.

T The Point of the *Summer-Solſtice* — P the Point of the *Winter-Solſtice*, Z the *Zenith* over our Heads, N the *Nadir-points* under our Feet.

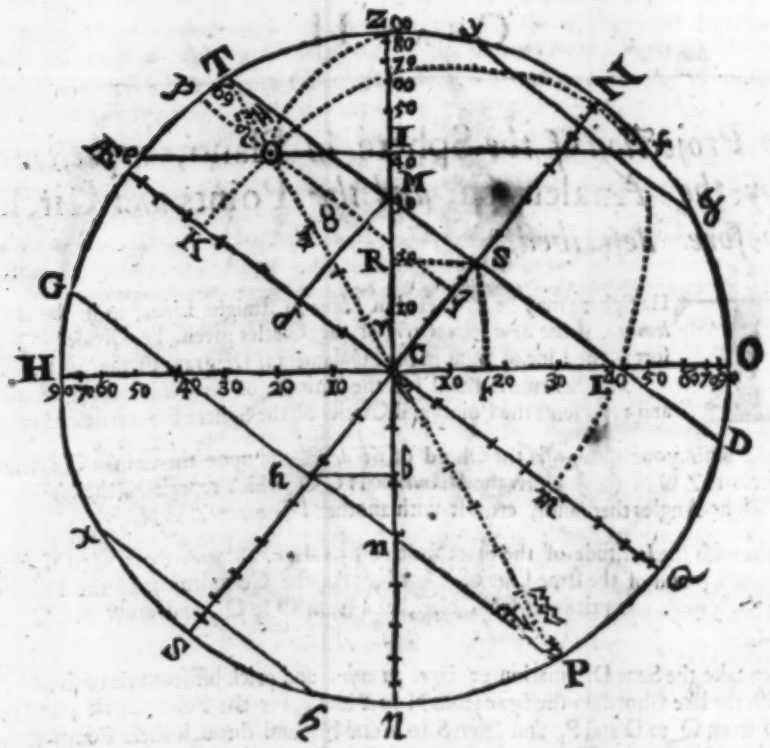
(2.) The greater Circles are HCO the *Horizon*, ZCN the *Axis* thereof, or Prime Vertical *Azimuth* of Eaſt and Weſt; HZON the great *Meridian*, and alſo the *Colure* of the *Summer* and *Winter-Solſtice*, — ÆCQ the *Equinoctial*; TCP the *Ecliptick*; SCN the *Axis* of the World, the Hour-Circle of 6; and alſo it repreſents the *Colure* of the *Equinoxes*.

(3.) The leſſer Circles are there repreſented, TD the Tropick of *Cancer*; GP the Tropick of *Capricorn*; Y*g* the *Arctick Circle*, about the Pole North; X♄ the *Antarctick-Circle*, or South-Pole.

(4.) Other Circles not deſcribed upon *Globes*, are there repreſented; E*f* repreſents a Parallel of Altitude called an *Almicanter*; the Prickt Arches Z⊖, and S*l* being *Ellipſes* repreſent the *Azimuths*, or Vertical-Circles.

The

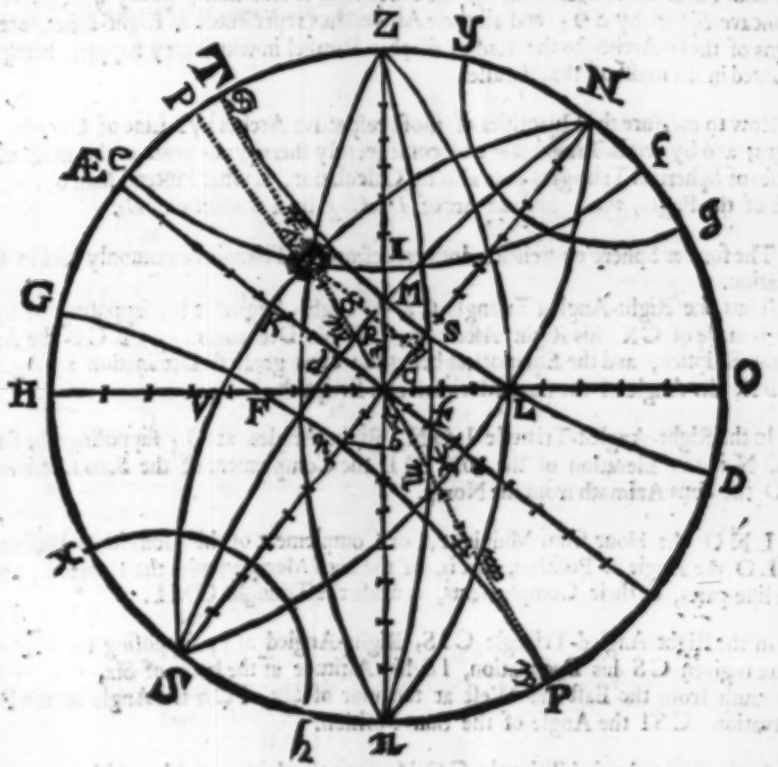
The Projection of the Sphere in Plano, *by Straight Lines or Signs.*



The Prickt Arches from the Poles, repreſent the *Meridian* or Hour-Circles, which are alſo *Ellipſes*; the Drawing thereof will be troubleſom, and for that reaſon is not mentioned; and how to ſhun them in the reſolution of any Propoſition of the *Sphere*, by Chords ſhall be ſhewn in the ſeveral Queſtions following; But the *Sphere* may be Projected in *Plano* by Circular-Lines, as in the general Aſtrolobe of *Gemma Triſius*, by help of the Tangent, and ½ Tangents in the Fundamental Diagram of the Scale, and by the Directions in the 4 Book 12 Chapter beforegoing, and will reſolve the ſame things; the directions ſhall be one and the ſame, in both, in Letters, and repreſents the ſame.

The

The Convex Sphere, *by* Circular Lines.



Any Line drawn Parallel to the Equinoctial Æ Q, as *p q*, T D. Y *g*: doth repreſent Parallels of Declination.

And any Line drawn Parallel to the Ecliptick T P, repreſents a Parallel of Latitude of the Stars and Planets in the Heavens.

(5.) Divers Arches relating to the motion of the Sun, and ſeen upon the *Globe*, and found by Calculation, are in the *Convex-Sphere*, repreſented in Right-Lines, and in the *Concave-Sphere* by Circular-Lines.

(1.) The Suns Amplitude, or Coaſt of Riſing and Setting, from the Eaſt and Weſt in the *Analemma*, is repreſented by C L in North Signs, and by C F in South Signs.

(2.) His Aſcentional-difference, or time of Riſing and Setting from Six in Summer by S L, in Winter by F H.

(3.) His Altitude at Six in Summer by R C, and his Depreſſion at Six in Winter, by C *b*.

(4.) His Azimuth at the hour of Six in Summer, by R S, or C I, equal to *h b* in Winter.

(5.) His Vertical-Altitude, or Altitude of Eaſt and Weſt, by M C in Summer, and his Depreſſion therein in Winter by C N.

(6.) His hour from Six being Eaſt and Weſt, in Summer by MS, in Winter by N *b*.

(7.) His Azimuth from the Eaſt and Weſt upon any Altitude, is repreſented in the Parallel of Altitude by the *Convex-Sphere*, where it Interſects the Parallel of Declination by I ☉; but in the *Concave-Sphere* may be meaſured on the Horizon H O, as C V, or C I, meaſured on the Line of half Tangents.

(8.) The Hour of the Day from Six, to any Altitude, is always repreſented in the ſaid Point of Interſection, in the Parallel of Declination, hereby $q\odot$, or in the Concave-Sphere by $S\odot$; and all theſe Arches thus repreſented in Right-Lines, are the Signs of thoſe Arches to the Radius of that Parallel in which they happen, being accounted in the midſt of that Parallel.

How to meaſure the Quantities of thoſe reſpective Arches by a Line of Chords and Signs, and by Half-Tangents; and conſequently thereby to reſolve the moſt uſeful Caſes of Spherical Triangles; as alſo by Calculation, is what I intend ſhall be the ſubject of the Pages, *viz.* and the Art of *Dialling* by a *Gnomical Scale*.

The former Sphere or Scheme doth repreſent the Triangles commonly uſed in Calculation.

Thus the Right-Angled Triangle $CK\odot$, Right-Angled at K; ſuppoſing the Sun at $\odot$, is made of CK, his Right Aſcention, $\odot K$ his Declination, — $KC\odot$ the Angle of the Ecliptick, and the Equinoctial being the Suns greateſt Declination 23 *deg.* 31′, $C\odot K$, the Angle of the Suns Meridian and Ecliptick.

In the Right-Angled-Triangle LON, Right-Angled at O; ſuppoſing the Sun at L ON is the Elevation of the Pole, NL the Complement of the Suns Declination, LO the Suns Azimuth from the North.

LNO the Hour from Midnight, or Complement of the Aſcentional-Difference, NLO the Angle of Poſition, that is, of the Suns Meridian with the Horizon; and of the like parts, or their Complements, is made the Triangle CML.

In the Right-Angled-Triangle CIS, Right-Angled at I; ſuppoſing the Sun at S, there is given CS his Declination, IS his Altitude at the hour of Six, CI the Suns Azimuth from the Eaſt and Weſt at the hour of Six, ICS the Angle of the Poles Elevation, CSI the Angle of the Suns Poſition.

In the Right-Angled-Triangle COM, ſuppoſe the Sun at M; dM the Suns Declination, Cd his hour from Six, CM the Altitude being Eaſt or Weſt, dCM the Latitude, dMC the Angle of the Suns Poſition.

In the Oblique-Angled Triangle $Z\odot N$, if the Sun be at $\odot$. ZN is the Complement of the Latitude, and $N\odot$ the Complement of the Suns Declination, or diſtance from the Pole. $Z\odot$ the Complement of the Suns Altitude, or height; $ZN\odot$ the Angle of the Hour from Noon; $NZ\odot$ the Suns Azimuth from the North-part of the Meridian; $Z\odot N$ the Angle of the Suns Poſition.

And thus we have ſhewed how the former Diagram or *Analemma* repreſents the *Spherical Triangles* uſed in Calculation; whereby, of the Six parts in each Triangle, if any three are given, the reſt may be found by Calculation from the Proportions, and that either by Addition and Subſtraction, by the Artificial Signs and Tangents; and what is reſolved by either of theſe ſorts of Tables, we will reſolve with the firſt Tables, and with Scale and Compaſſes, that you may ſee the near agreement betwixt them.

CHAP. III.

Chap. III.

How to Calculate the Sun's true place.

This Propoſition is propounded, in the firſt place, becauſe many others depend upon it; According to the *Hypotheſis* of *Tycho*, it is to be ſuggeſted, and there is aſcribed to the Sun a Triple Motion; firſt, a Motion upon his own Centre, whereby he finiſheth one Revolution in 26 Days.

2. A daily motion from the Eaſt into the Weſt, whereby he cauſeth the Day and Night.

3. An oppoſite Motion from the Weſt into the Eaſt, called the Annual Motion, whereby he runs once round in a Year through the whole Ecliptick, moving near a *degree* in a Day; and thereby cauſeth the ſeveral Seaſons of the Year.

The two later Motions are fancied out unto us, by a Man turning a *Crane*-Wheel, or *Grind-ſtone* 365 times round, while a Worm ſtruggling againſt, and contrary to that Motion, creeps once round the contrary way, but Obliquely and a ſlope; that is, from the further ſide of the Wheel, towards the hithermoſt; and by this Motion the Sun is ſuppoſed to deſcribe the Ecliptick-Line, and continually to inſiſt in this Courſe; the other Planets, except the Moon, moving round him, or following after him, like Birds flying in the Air, being ſubject to his Motions, and many of their own beſides; many of which Motions are removed by the *Copernican* ſuppoſition of the Earths Motion, which is a ſubject of much controverſy among the Learned; However, be it either the one, or the other, the Propoſitions hereafter Reſolved, vary not, by reaſon thereof: And ſo the Sun being ſuppoſed not to vary from under the Ecliptick in reſpect of Latitude; the Propoſition and Quære, in effect is what Longitude he hath therein, from the neareſt Equinoctial-Point, which may be found within a Degree for his Courſe in each day, from his Entrance into each Sign, from that day of the Month.

The Day of the Month the Sun enters into each Sign.

♈ Aries,	*March* 10.
♉ Taurus,	*April* 9.
♊ Gemini,	*May* 11.
♋ Cancer,	*June* 12.
♌ Leo,	*July* 13.
♍ Virgo,	*Auguſt* 13.
♎ Libra,	*September* 13.
♏ Scorpio,	*October* 13.
♐ Sagitarius,	*November* 11.
♑ Capricornus,	*Decem.* 11.
♒ Aquarius,	*January* 9.
♓ Piſces,	*February* 8.

1. If the number of the Day of the Month given, exceed the number of that Day, in which the Sun enters into any Sign; Subſtract the leſſer Number from the greater, and the Remainer is the Degree of the Sign, that the Sun poſſeſſeth.

Prob. I.

Example.

ON the 12 of *May* I would find the Suns true place by the former Rules; The Sun enters *Gemini May* 11; which Substract from 12, the Remainer is 1, which shews the Sun to be in 1 *deg.* of *Gemini* the third Sign; that is, 61 *degr.* from the next Equinoctial-Point.

2. Example.

Let it be required to know the Suns Place the 4th of *November*; on the 11 day of that Month the Sun enters *Sagitarius*, and the 13th day of *September* he enters *Libra*: betwixt the 13 of *September*, and the 4 of *November* is 52 days, and consequently 52 *degr.* from the Equinoctial-Point *Libra*; then 30 taken from 52, there remains 22 *degr.* the Suns place in *Scorpio*, which is the thing required.

But here is a nearer Rule yet than this, to find the Suns place exactly, and that is by Mr. *Vincent Wing*'s *Hypotheſis*, and Tables in *Aſtronomia Britanica*, how to Calculate his true place from Earth, the Rule is,

First, enter the Table of the Middle-Motion of the Sun, and write out the *Epocha* next going before the time given, under which ſet the Motion diſtinctly belonging to the Years, Months, and Days, and Hours, and Minutes, if any be; (only in the *Biſſextile* or *Leap-Years*,) after *February* a Day is to be added to the number of Days given; then adding them all together, the ſum will be the Middle-Motion of the Sun for the time given.

As for Example.

Suppoſe the time given be the 12 of *May* at Noon 1667, at which time the Suns place is required.

Time given.	Longitude ☉				Apog. ☉			
	S	D	M	S	S	D	M	S
The *Epocha*	9	20	24	49	3	6	45	5
1661 years In-	11	29	33	07	0	0	6	10
cluding 6 *May*.	3	28	16	39				20
Days 12.	0	11	49	40				2
The Suns Mean-motion, or Longitude	2	00	04	15	3	6	51	37

2. Substract the *Apog.* of the Sun from his Mean-Longitude, and the Remain will be his Mean Anomaly.

Example.	S	D	M	S
The Suns Mean-Longitude is ——	2	00	04	15
The *Apogeum* Substracted ——	3	06	51	37
The Suns *Anomaly*. ——	10	23	12	38

With the Suns *Anomaly* enter the Table of his Equation with the Sign on the Head and the *deg.* descending on the left hand, if the Number thereof be under 6 Signs; but if it be more than 6 Signs, enter with the Sign in the bottom, and the *degr.* ascending on the right hand, and in the common-Angle you have the Equation answering thereunto; only you must, if need require, remember to take the Proportional part.

Example.

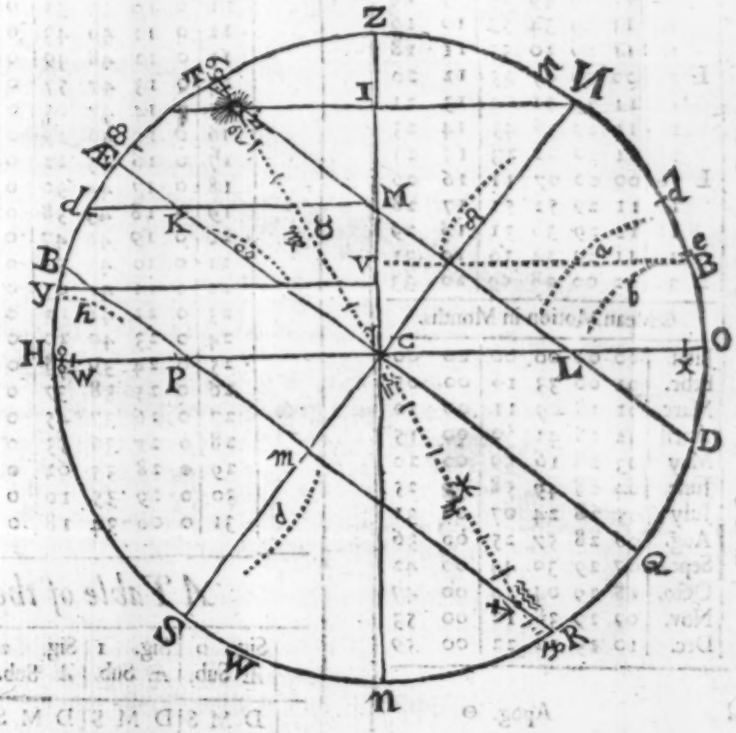
	S	D	M	S
In the Table of Equation answering to 23 *degr.* is ——	0	01	11	51
The Suns Mean-Longitude, add ——	2	00	04	15
The Suns true Longitude. ——	2	01	16	06

Therefore the true place of the Sun is in 1 *degr.* 16 *min.* 6 *ſeconds* of *Gemini*.

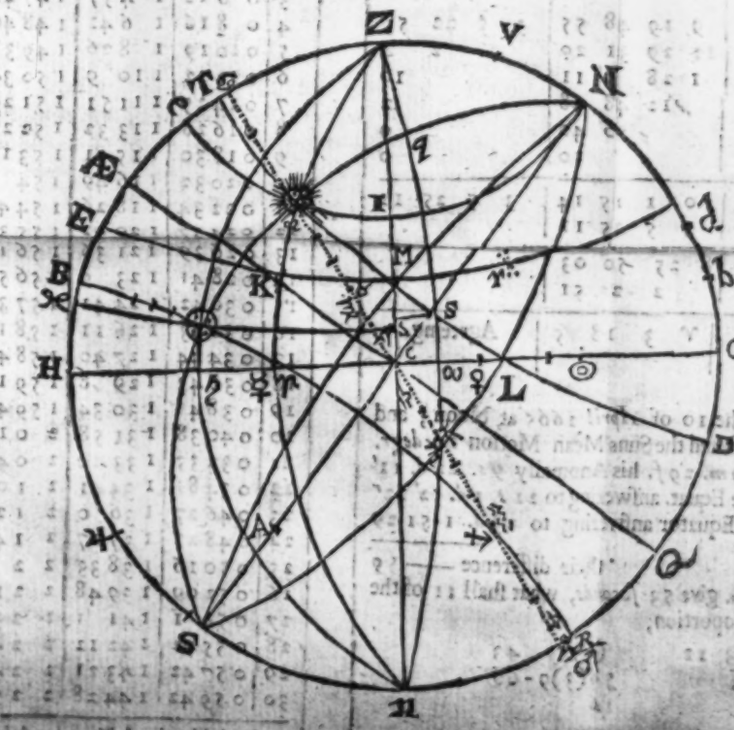
Another Example.

In the Year 1583 *March* 14 at Noon, in the Meridian of *Uraneburg* in *Denmark*, thrice Noble *Tycho-Brahe*, moſt excellently obſerved the Suns true place in 3 *deg.* 17 *min.* 40 *ſeconds* of ♈. The time at *London* was 1583 *March* 13 day 23 *h.* 8 *m.*

The *Convex-Sphere*, which resolves all the most useful Problems in *Astronomy*, by the Direction of 13 Problems following.



The *Concave-Sphere*, which resolves 13 Problems, *viz.* and by them may be resolved, most of the useful Problems in *Astronomy*.



A Table of the Suns Mean Motion.

The Apoche, or Radius.

Year.	Longit. ☉ S	D	M	S	Apog. ☉ S	D	M	S
Ch. 1	9	07	59	51	2	08	20	03
1581	9	19	48	55	3	05	22	55
1601	9	19	57	54	3	50	43	28
1621	9	20	06	52	3	06	04	00
1641	9	20	15	51	3	06	24	33
1661	9	20	24	49	3	06	45	05
1681	9	20	33	48	3	07	05	38

☉ Mean Motion in Years above 20.

20	0	00	08	59	0	00	20	33
40	0	00	17	57	0	00	41	05
60	0	00	26	56	0	11	01	38
80	0	00	35	54	0	11	22	10
100	0	00	44	53	0	11	42	43
200	0	02	29	45	0	03	25	26
300	0	02	14	38	0	05	08	08
400	0	02	59	31	0	06	50	51
500	0	03	44	23	0	08	33	34
600	0	04	29	16	0	10	16	17
700	0	05	14	09	0	11	59	00
800	0	05	59	01	0	13	41	42
900	0	06	43	54	0	15	24	25
1000	0	07	28	47	0	17	07	08
2000	0	14	57	34	1	04	14	15
3000	0	22	26	21	1	21	21	22
4000	0	29	55	08	2	08	28	30
5000	1	07	33	55	2	25	35	37
6000	1	14	52	42	3	12	42	44

☉ Mean Motion in years under 20.

	Years.	Longit. ☉ S	D	M	S	Apog. ☉ M	S
	1	11	29	45	40	1	02
	2	11	29	31	20	2	04
	3	11	29	16	59	3	05
L	4	00	00	01	48	4	07
	5	11	29	47	28	5	08
	6	11	29	33	07	6	10
	7	11	29	10	47	7	12
L	8	00	00	03	35	8	13
	9	11	29	49	15	9	14
	10	11	29	34	55	10	16
	11	11	29	20	35	11	18
L	12	00	00	05	23	12	20
	13	11	29	51	03	13	21
	14	11	29	36	43	14	23
	15	11	29	22	23	15	25
L	16	00	00	07	11	16	26
	17	11	29	52	51	17	28
	18	11	29	38	31	18	29
	19	11	29	24	10	19	31
L	20	00	00	08	59	20	33

☉ Mean Motion in Months.

Janu.	00	00	00	00	00	00
Febr.	01	00	33	18	00	05
Marc.	01	28	09	11	00	10
April	02	28	42	30	00	15
May	03	28	16	39	00	20
June	04	28	49	58	00	25
July	05	28	24	07	00	31
Aug.	06	28	57	25	00	36
Sept.	07	29	30	44	00	42
Octo.	08	29	04	54	00	47
Nov.	09	29	38	12	00	53
Dec.	10	29	12	22	00	59

The Calculation.

	Long. ☉ S	D	M	S	Apog. ☉ S	D	M	S
The ☉ Apocha.								
☞ 1581.	9	19	48	55	3	5	22	55
Years added 2	11	29	31	20			2	4
March.	1	28	9	11				10
Days 13		12	48	48				2
Hours 23			56	40				0
Minutes 8				20				0
The Suns Mean Motion.	0	1	15	14	3	5	25	11
Apogeum Substract.	3	5	25	11				
The Anomaly of ☉	8	25	50	03				
The Equator added to 1 15′ 14′		2	2	51				
The Suns true place, with Observation.	♈	3	18	5	Agreeing.			

(3) Example the time given the 10 of *April* 1665 at Noon; and admit by the former Rules we have found the Suns Mean Motion 29 *degr.* 0 *min.* 30′ his Apogeum 3 *s.* 6 *d.* 49 *m.* 29 *s.* his Anomally 9 *s.* 22 *d.* 11′ 1″; first find a Proportional part, the Equat. answering to 22 *s.* 1 *d.* 52′ 22″

The Equator answering to 23 *d.* 1 51 29

their difference —— 59

Then I say, if 1 *deg.* or 60 *min.* give 53 *seconds*, what shall 11 of the Anomaly give? by the Rule of proportion,

60 : 53 11

53

(4) 43

58 (3) 9 - 60

(6

A Table of the Suns Mean Motion.

	Longit. ☉ S	D	M	S	Apog. M	S	H	Long. ☉ D	M	S	M	Lon. ☉ M	S
1	0	0	59	08	0	0	1	0	2	24	31	1	17
2	0	01	58	17	0	0	2	0	4	56	32	1	19
3	0	02	57	25	0	0	3	0	7	24	33	1	21
4	0	03	56	33	0	1	4	0	9	51	34	1	24
5	0	04	55	42	0	1	5	0	12	19	35	1	26
6	0	05	54	50	0	1	6	0	14	47	36	1	29
7	0	06	53	58	0	1	7	0	17	15	37	1	31
8	0	07	53	07	0	1	8	0	19	43	38	1	34
9	0	08	52	15	0	1	9	0	22	11	39	1	36
10	0	09	51	23	0	2	10	0	24	38	40	1	39
11	0	10	50	31	0	2	11	0	27	6	41	1	41
12	0	11	49	40	0	2	12	0	29	34	42	1	43
13	0	12	48	49	0	2	13	0	32	2	43	1	46
14	0	13	47	57	0	2	14	0	34	30	44	1	48
15	0	14	47	05	0	2	15	0	36	58	45	1	51
16	0	15	46	13	0	3	16	0	39	25	46	1	53
17	0	16	45	22	0	3	17	0	41	53	47	1	56
18	0	17	44	30	0	3	18	0	44	21	48	1	58
19	0	18	43	38	0	3	19	0	46	48	49	2	01
20	0	19	42	47	0	3	20	0	49	17	50	2	03
21	0	20	41	55	0	3	21	0	51	45	51	2	06
22	0	21	41	03	0	4	22	0	54	13	52	2	08
23	0	22	41	12	0	4	23	0	56	40	53	2	11
24	0	23	40	20	0	4	24	0	59	8	54	2	13
25	0	24	39	28	0	4	25	1	01	34	55	2	18
26	0	25	38	37	0	4	26	1	04	04	56	2	18
27	0	26	37	45	0	4	27	1	06	32	57	2	20
28	0	27	36	53	0	5	28	1	09	00	58	2	23
29	0	28	35	02	0	5	29	1	11	27	59	2	25
30	0	29	35	10	0	5	30	1	13	55	60	2	28
31	0	00	34	18	0	5	M	*m*	*se.*	*th.*	*sec*	*sec*	*th.*

A Table of the Suns Equation.

Sig. 0 Æ Sub.				Sig. 1 Æ Sub.			Sig. 2 Æ Sub.			Sig. 3 Æ Sub.			Sig. 4 Æ Sub.			Sig. 5 Æ Sub.			
	D	M	S	D	M	S	D	M	S	D	M	S	D	S	M	D	M	S	
0	0	0	0	0	59	32	1	44	28	2	2	54	1	48	23	1	3	26	30
1	0	2	5	1	1	21	1	45	34	2	2	56	1	47	20	1	1	32	29
2	0	4	9	1	3	10	1	46	38	2	2	56	1	46	15	0	59	37	28
3	0	6	12	1	4	57	1	47	41	2	2	55	1	45	9	0	57	40	27
4	0	8	16	1	6	42	1	48	40	2	2	52	1	44	1	0	55	42	26
5	0	10	19	1	8	26	1	49	38	2	2	47	1	42	50	0	53	43	25
6	0	12	22	1	10	9	1	50	34	2	2	39	1	41	37	0	51	43	24
7	0	14	25	1	11	51	1	51	29	2	2	29	1	40	22	0	49	42	23
8	0	16	28	1	13	32	1	52	22	2	2	17	1	39	4	0	45	39	22
9	0	18	30	1	15	11	1	53	13	2	2	2	1	37	45	0	45	35	21
10	0	20	32	1	16	49	1	54	1	2	1	46	1	36	24	0	43	31	20
11	0	22	34	1	18	26	1	54	43	2	1	29	1	35	3	0	41	26	19
12	0	24	37	1	20	02	1	55	31	2	1	7	1	33	20	0	39	20	18
13	0	26	39	1	21	36	1	56	14	2	0	44	1	32	2	0	37	14	17
14	0	28	41	1	23	9	1	56	55	2	0	18	1	30	44	0	5		16
15	0	30	42	1	24	41	1	57	34	1	59	49	1	29	13	0	3	6	15
16	0	32	43	1	26	11	1	58	10	1	59	19	1	27	41	0	3	50	14
17	0	34	44	1	27	40	1	58	44	1	58	47	1	26	7	0	2	31	13
18	0	36	43	1	29	8	1	59	16	1	58	12	1	24	32	0	26	1	12
19	0	38	41	1	30	34	1	59	46	1	57	35	1	22	56	0	24	1	11
20	0	40	38	1	31	58	2	0	14	1	56	56	1	21	18	0	22	2	10
21	0	32	35	1	33	20	2	0	40	1	56	14	1	19	38	0	19	5	
22	0	34	81	1	34	41	2	1	04	1	55	30	1	17	56	0	17	48	
23	0	46	27	1	36	0	2	1	26	1	54	44	1	16	12	0	15	36	
24	0	48	22	1	37	17	2	1	46	1	53	56	1	14	26	0	13	33	
25	0	50	16	1	38	33	2	2	3	1	53	5	1	12	40	0	11	10	
26	0	52	09	1	39	48	2	2	18	1	52	12	1	10	52	0	8	57	
27	0	54	1	1	41	1	2	2	30	1	51	18	1	9	2	0	6	43	
28	0	55	52	1	42	12	2	2	40	1	50	21	1	7	11	0	4	29	
29	0	57	42	1	43	21	2	2	48	1	49	23	1	5	18	0	2	15	
30	0	59	42	1	44	28	2	2	54	1	48	23	1	3	36	0	0	0	
	Add Sig. 11			Add Sig. 10			Add Sig. 9			Add Sig. 8			Add Sig. 7			Add Sig. 6			

Place this Table between Pag. 106 and 107.

Multiply 53 by 11, the Product is 583, which Divide by 60, the Quotient will be $9''\,\frac{43}{60}$; and becauſe the Equation decreaſes I. Subſtract it from the Equa. anſwering 22 *degr.* which is 1 *d.* 52″ - 12″ for the true Equation deſired, which according to the Title, being added to the Suns Mean-Longitude, giveth the true place of the Sun required.

Example.

	S	D	′	″
The Suns Mean-Longitude. —	0	29	00	30
The Equation added. ———		1	52	12
The Suns true Longitude. —	1	00	52	42

D. ″ ″

Therefore the Suns true place is in 0 52 : 42 of *Taurus*; theſe Examples are ſufficient for Direction, to find the Suns true place at any time.

PROBL. II.

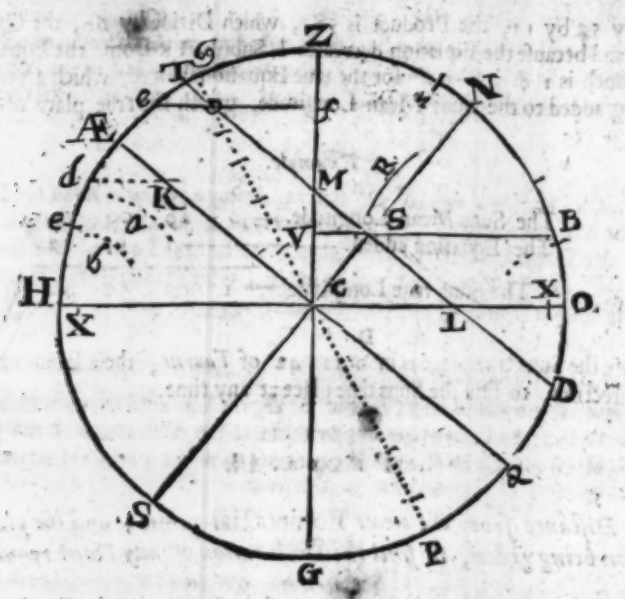
The Suns Diſtance from the next Equinoctial-point; *and his greateſt Declination being given, to find the Declination of any Point required.*

WIth your *Compaſſes* take the Chord of 60 *degr.* upon the Centre C, deſcribe the Circle H Z O N, and draw the Diameter H C O, which repreſents the Horizon, and at Right-Angles, or perpendicular thereunto, draw Z C N, the Vertical Azimuth of Eaſt and Weſt, and take the Latitude of the Place, as in this Example, is 51 *d.* 28 *m.* and prick it from O to N, and from H to S, and draw the *Axis* or *Meridian* of the Hour of Six N C S; then prick from Z to Æ, and from N to Q 51 *degr.* 28 *min*, and draw the Equinoctial Line Æ C Q; then the Suns place being given, take 23 *deg.* 31 *m.* and prick from Æ to ♋, and from Q to P, and draw the prickt Line ♋ C P; then take the Suns Diſtance from the next Equin.-Point, which in this Example ſhall be 61 *deg.* 18 *m.* out of the Line of Signs, and prick it from C to ☉, and through ☉ ⊕ draw a Parallel-Line to the Equinoctial, as T D, and it ſhall be a Parallel of Declination, and where it cuts the outward Meridian, as at T; apply the Diſtance Æ T to the Line of Chords, and you have the Declination 20 *degr.* 30 *min.* which was required; Or you may take the neareſt Diſtance from ☉ to the Equator, and apply it to the Line of Signs, and that will give you the Declination 20 *degr.* 30 *min.* as before; and if through ☉ ⊕ you draw a Line Parallel to the Horizon H O, as *e f*, it is a Parallel of the Suns Altitude, and ſo have you the Sphere Orthographically in Right-Lines in the *Convex-Sphere*; and if you follow the directions of the uſe of Tangents, and half Tangents in the 12 Chap. of the fourth Book of the Deſcription of the *Globe* in *Plano*, you have the Sphere projected in Plain and Circular Lines, and fitted for the uſe of divers Queſtions; the Direction in both Spheres by the Letters ſignify the ſame thing; but obſerve what you are directed by Signs in the *Convex-Sphere*, is likewiſe to be done by ⅓ Tangents in the *Concave-Sphere*.

By the Tables in the Right-Angled Triangle C K ☉; we have given, firſt the *Hypothenuſe* C ☉ 61 *degrees* 18′; ſecondly, the Angle K C ☉ 23 *degr.* 31′, hence to find K ☉, the Rule is, as the *Radius* is in proportion 10
to the Sign of the Suns greateſt Decl. 23 *d.* 31′ K C ☉ ——— 960099
So is the Sign of the Suns diſtance from the next Equinoctial-Point
61 *degrees* 18 *min.* C ☉ — 994307
to the Sign of his Declination required 20 *degrees*, 30′ ——— K ⊕ — 954406

Or extend the *Compaſſes* in the Line of Artificial Signs from 90 *degr.* to 23 *degr.* 30 *min.* the ſame extent will give the diſtance from the Suns Place, to his Declination.

The



The Sun being either in 1 *deg.* 18 *min.* of *Gemini*, or 29 *deg.* 42 *min.* of *Capricorn*, or 1 *degr.* 18 ′ of *Sagitarius*, or 28 *degr.* 42 *min.* of *Cancer*; that is, 61 *degr.* 18 *min.* from the next Equinoctial-Point; the Declination will be found to be 20 *degrees* 30 *minutes.*

Probl. III.

Having the Suns greateſt Declination, and his Diſtance from the next Equinoctial-Point; *to find his* Right-Aſcention.

IN the Foregoing Scheme, having drawn the Parallel of the Suns Declination TD, paſſing through the Place at ✳ the extent S⊕, is the Sign of the Suns Right-Aſcention from the next neareſt Equinoctial-Point, to the *Radius* of the Parallel TD; and therefore place the extent ST from C to X, and upon X as a Centre with the extent S⊕, deſcribe the Arch at *k*, a Ruler laid from the Centre juſt touching the extremity of that Arch, finds the Point N in the Limb of the Meridian or Quadrant, and the Arch ON, applyed to the Line of Chords, is 59 *degr.* 09 *min.* and ſo much is the Suns Right-Aſcenſion *in* the firſt quarter of the Ecliptick.

In the Triangle CK⊕ we have given as before, (1.) the Angle of the Suns greateſt Declination KC⊕ 23 *degr.* 31 *min.* (2.) the Longitude of the Sun from the next Equinoctial-Point *Aries* C⊕ 61 *degr.* 18 *min.* hence to find the Suns Right-Aſcention, the Rule is,

As the *Radius* ——— 10
to the Tangent of the diſtance 61 *degr.* 18 *min.* C⊕ ——— 1026162
So is the Co-Sign of the Suns greateſt Decl. 23 *deg.* 31 ′ KC⊕ — 996234

to the Tangent of the Right-Aſcention CK 59 *deg.* 9 *m.* — 1022396

Or in the *Concave-Sphere*; if you draw the Meridian from N through ⊕ to S, whoſe Centre will be found upon the Equator, it will cut the Equinoctial in K; meaſure the diſtance GK on the Line of half-Tangents, and you have 59 *d.* 09′, as before.

Or extend the *Compaſſes* from 90 *d.* to 66 *d.* 29, the ſame diſtance will reach from 61 *deg.* 18 *m.* to 59 *deg.* 9 *min.* which is the Suns Right-Aſcention in 61 *deg.* 18 ♊.

But

But this you are to obſerve, that if the Right-Aſcention ſought, be in the ſecond Quadrant ♋ ♌ ♍, then you are to take the Complement of the Arch found to 180 *deg.* if in the third Quadrant ♎ ♏ ♐, adde 180 *deg.* to the Arch found; but in the laſt Quadrant, Subſtract the Arch found from the whole Circle 360 *degr.* and you ſhall have the Right-Aſcention deſired.

Example 2.

The Sun in 28 *degr.* 42 *min.* of ♋, that is, 61 *degr.* 18 *min.* from the Equinoctial Point ♎; the Rule is as before. As the *Radius* is to the Co-Sign of the greateſt Declination, ſo is the Tangent of the Suns diſtance from the next Equinoctial-Point 61 *degr.* 18 *min.* to the Tangent of 59 *degr.* 09 as before, which taken from 180, is 130 *deg.* 51 *min.* which is the Suns Right-Aſcention in 28 *degr.* 42 *min.* of *Cancer.*

Example 3.

The Sun in 1 *degr.* 18 *min.* of ♐, that is, 61 *degr.* 18 *min.* from the next Equinoctial-Point ♎, the work is the ſame as before; therefore to the Arch found, I add 180 *degr.* a Semi-Circle; ſo 59 *deg.* 09 *min.* and 180, makes 239 *deg.* 09 *min.* the Right-Aſcention of the Sun ſought in 1 *deg.* 18 *min.* of *Sagitarius* ♐.

Example 4.

The Sun in 28 *degr.* 42 *min.* of *Capricorn*, 61 *deg.* 18 *min.* from the next Equinoctial Point ♈, the operation is the ſame with the former Example; wherefore Subſtract the Arch found 59 *deg.* 09 *min.* from the whole Circle 360 *deg.* and there will remain 200 *deg.* 51 *min.* which is the Suns Right-Aſcention in 28 *deg.* 42 *min.* of ♑ *Capricorn.*

PROB. IV.

The Elevation of the Pole, *and Declination of the* Sun *being given; to find the* Aſcentional-Difference.

THis is repreſented in the Figure by SL in the Parallel of Declination, and it is therefore to be reduced into the common *Radius*, therefore take the *Radius* of the Parallel S T, and prick it from C to X, as before; then take the extent SL, and ſetting one Foot upon X, with the other draw the part of an Arch at *a*, lay a Ruler from C, that it may juſt touch the outſide thereof, and it cuts the Circle in *d*, and take the Chord or Extent H *d*; and you will find it 28 *deg.* 0 *min.* which being converted into Time, is an Hour 52 *min.* and ſo much doth the Sun Riſe before, and Set after Six in *Summer*; but ſo much doth he Riſe after, and Set before Six in *Winter*, when he hath the ſame Declination *South.*

In the Right-Angled Spherical Triangle SLC are known. 1. SCL the Complement of the Poles Elevation 38 *deg.* 32 *min.* 2. The Suns Declination 20 *deg.* 30 *min.* hence to find the Aſcentional Difference SL.

As the *Radius* 90 *deg.* is in Proportion ——————— 10
to the Tangent of the Latit. 51 *deg.* 28 *min.* SCL — 1009887
So is the Tangent of the Suns Declination 20 *deg.* 30′ SC - 957273

to the Sign of SL the Aſcentional-difference 28 *d.* 00 *m.* - 967160

Extend the *Compaſſes* on the Artificial-Lines of Signs and Tangents, and you will find it, as before; or if you take the diſtance NS, and prick it from S to K, and lay the Ruler from C over L, it will cut the Arch of the Meridian in *d*; then Meaſure the diſtance N *d* on the Line of Chords, and it will be 28 *deg.* 00 *min.* as before found, that is one Hour 52 *min.*

PROBL.

Probl. V.

The Suns Right-Aſcention, *and his* Aſcentional-difference *being given; to find his* Oblique-Aſcention, *and* Deſcention.

TO perform this, you muſt obſerve theſe 2 following Rules. 1. If the Suns Declination be North, you muſt Subſtract the Aſcentional-difference from the Right-Aſcention, and the Remain will be the Oblique-Aſcention; but if you add them together, the ſum will be the Oblique Deſcention. 2. If his Declination be *South*, add the Aſcentional-difference, and the Right Aſcention together, the ſum will be the Oblique-Aſcention; but if you make Subſtraction, the Remainer will be the Oblique-Deſcention.

Admit the Sun is in the 1 *deg.* 18 *min.* of *Gemini* by the ſecond Problem, his Right-Aſcention is 59 *deg.* 09 *min.* and his Aſcentional-difference by the 4 Problem, is 28 *deg.* 0 *min.* therefore according to the firſt Rule, becauſe his Declination is *North*, the difference thereof 31 *deg.* 09 *min.* is the Suns Oblique-Aſcention, and the ſum of them 87 *deg.* 09 *min.* his Oblique-Deſcention.

Probl. VI.

To find the time of Sun-Riſing, *and* Setting, *with the length of the* Day *and* Night.

YOu muſt find the Aſcentoinal-difference by the 4 Problem, which converted into Time, allowing 4 *min.* of an hour for every *degr.* and 4″ ſeconds for every *min.* and the ſum of Hours and Minutes, is his difference of Riſing and Setting before or after the hour of Six, which was found before to be 28 *deg.* or 1 hour 52 *min.*

Therefore when the Sun is in Northern Signs, add the ſum to Six, and the Total is the Semi-diurnal Arch, as in this Example, is 7 *hours* 5′2, or time of Sun-ſetting, and Subſtract it from Six, and the Remain is 4 *h.* 8′. *m* the time of Sun-Riſing; double 7 *ho.* 5′2 *m*, it is 15 *ho.* 4′4, the length of the Day; Subſtract it from 24 *ho.* 00 *m.* and the Remain is 8 *ho.* 16 *m.* the length of the Night the 12 of *May*, in Latitude 51 *deg.* 28 *min.* at *Briſtol*.

But if the Sun is in Southern Signs, make Subſtraction, as in this Example; the Sun having 20 *deg.* 30 *min.* South Declination, or in 1 *deg.* 18 *min.* ♐; Subſtract 1 *ho.* 5′2 from 6, the Remain is 4 *ho.* 08 *m.* for the time of Sun-Setting, double it, and it is 8 *ho.* 16 *m.* the length of the day; add 1 *ho.* 52 *m.* to 6, the ſum is 7 *ho.* 52 *m.* is the time of Sun-Riſing; double it, it is 15 *ho.* 44 *m.* the length of the Night, in Latitude 51 *deg.* 28 *m.* in 1 *deg.* 18 *m.* of *Sagitarius*.

Probl. VII.

The Elevation of the Pole, *and* Declination *of the* Sun *being given; to find his* Amplitude.

MEaſure the extent CL with the *Compaſſes* in the Line of Signs, and it will reach to 34 *degr.* 40 *min.* and ſo much doth the Sun Riſe and Set to the Northward of the Eaſt and Weſt in the Latitude of *Briſtol*, when his Declination is 20 *deg.* 30 *min.* North; but he Riſeth and Setteth ſo much to the Southward of the Eaſt and Weſt, when his Declination is ſo much South.

Now on the Concave-Sphere, the extent CL on the Horizon, applyed to the Line of half-Tangents, is 34 *deg.* 40 *min.* the Amplitude, as before.

If

If the Suns Parallel of Declination doth not meet with the Horizontal-Line HO, as in Regions far North, the Sun doth not Rise nor Set.

In the Right-Angled Spherical-Traingle LOC of the 4 Problem, having the Angle LCO, the Complement of the Latitude 38 *degr.* 32 *min.* and LO the Suns Declination 20 *degr.* 30 *min.* in 1 *d.* 18 *m.* ♊ his Amplitude by Calculation may be found thus.

The Artificial Lines by this Rule answers the same. { As the Co-Sign of the Latitude 51 *deg.* 28 *min.* LCO — 979446 is to the *Radius* 90 *degr.* ——— 10
So is the Sign of the Declination 20 *degr.* 30′ LO ——— 954432
to the Sign of the Amplitude CL 34 *deg.* 40 *min.* — 974986

This Rule is the common Rule Mariners make use of for the finding of the Variation of the *Compass* at Sea, by comparing the Coast, or bearing of the Sun, observed by an Amplitude or Azimuth-Compass at the Suns Rising or Setting, and by his bearing, found by these Rules beforegoing, the difference sheweth the Variation.

As for Example.

Admit you observed the Suns Amplitude of Rising or Setting by your *Compass* in the first Chap. and fifth Book of the Art of *Surveying* described.

And by the *Compass* found, the Magnetical Amplitude 45 *d.* 55′ compl. 44 *d.* 05′ N.
By the Rules beforegoing find the true Amplitude, — 34 *d.* 40 compl. 55 *d.* 20′ N.

Substract the less out of the greater, the difference 11 *d.* 15 *m.* Variation.

And by reason the Magnetical Amplitude is more than the true Amplitude, therefore the Variation is 11 *degr.* 15 *min.* which is one Point Westerly; and if you are bound to a place that bear North of you, you must Sail upon the North by West Point, or if you bare West, you must Sail W and by S, and if South, the Course must be South and by East; or if you bear East, then the Course must be East and by North, to make good a North, or West, or South, or East Course; and so of all the rest of the Points you must allow in like manner.

2. But admit the Magnetical Amplitude observed by the *Compass*, were but 23 *deg.* 25 *min.* and the true Amplitude by the former Rules found to be 34 *degr.* 40 *min.* the upper Substract from the lower, the difference is 11 *degr.* 15 *min.* and by reason the Magnetical Amplitude is less than the true Amplitude, and the difference 11 *degr.* 15 *m.* which is one Point Variation Easterly; and so the North Point is the N by E Point, and N E is the N E by E, and E is E by S, and South is S by W, and W is W by N Point of your *Sailing Compass*; when you have such a Variation, and the Complement of the Amplitude is the Suns Azimuth from the North or South part of the Meridian, according as your Declination is. And this is sufficient for an Example to find the Variation of the *Compass* in any place or time.

As likewise by his Oblique-Ascension, and Ascensional difference; or by the Suns being East and West by the following Rules, or by the Suns Azimuth at the hour of Six; as likewise his Azimuth at any other time or place observed, as shall be shewn for the help and benefit of young *Mariners*.

Prob. VIII.

Having the Latitude of the Place, and the Suns Declination, to find the time when the Sun cometh to be due East *and* Weſt.

IN the Parallel of Declination, the hour from Six is repreſented by S M; with that extent upon the Point X draw the Arch *b* the Ruler laid from C to the outward edge of the ſaid Arch, cuts the Circle at (*e*,) the diſtance O *e* applyed to the Line of Chords ſheweth 17 *deg.* 20 *min.* it converted into Time is 1 *h.* 9 *m.* 20 *ſec.* and ſo much after Six in the Morning, and before Six in the Afternoon, will the Sun be due Eaſt and Weſt; by the Concave-Sphere, if you lay a Ruler from A over M, it cuts the Limb in (*e*,) meaſure N *e* on the Line of Chords, and it is the ſame 17 *deg.* 20 *min.* the Rule by Artificial Signs and Tangents holds as by Calculation, *viz.*

Suppoſe the Latitude 51 *degrees* 28 *min.* and Declination North 20 *degrees* 30 *min.* therefore in the Right-Angled Spherical Triangle Z N M are given (1) Z N the Complement of the Latitude 38 *degr.* 30 *min.* (2) N M the Complement of the Suns Declination 69 *degr.* 30 *min.* Then I ſay.

As the *Radius* 90 is in proportion ——— 10
To the Co-Tangent of the Declination 69 *degr.* 30 *min.* N M —— 957273
ſo is the Tangent of Z N compl. of Latitude 38 *degr.* 32 *min.* — 990112

is to the Co-Sign of Z N M 17 *deg.* 20 *min.* which Reduced is 1 *h.* 9 *m.* of time, as before. ——— 947385

Which 1 *h.* 9 *m.* added to 6 *h.* is 7 *h.* 9 *m.* the moment in the Morning, the Sun will be due Eaſt; and if you Subſtract 1 *h.* 9 *m.* 20 *ſec.* from 6 *h.* 00 *m.* and the Remain will be 4 *h.* 50 *m.* 40 *ſec.* the moment in the Afternoon the Sun will be due Weſt.

Prob. IX.

The Elevation of the Pole, *and the Declination of the* Sun *being given; to find the Suns Altitude when he is due* Eaſt *and* Weſt.

MEaſure the extent C M on the Vertical-Circle, and apply it to the Line of Signs, and it will reach to 26 *degr.* 36 *min.* or the ſame diſtance taken of the Concave-Sphere, and applyed to the Line of ½ Tangents, ſhews the ſame number, and ſo much is his Altitude ſought in Summer; but when he hath the like Declination South, then ſo much is his Depreſſion under the Horizon in Winter, when he is Eaſt and Weſt; if the Suns Parallel of Declination T M doth not meet with the prime Vertical Circle C Z, the Sun cometh not to the Eaſt and Weſt, as it happeneth many times in ſmall Latitudes, or Countreys betwixt the Tropicks.

In the former Diagram, the Suns Altitude when he is due Eaſt and Weſt, iſhewed by the Arch C M, wherefore in the Triangle C V M we have given, (1) the Suns Declination V M 20 *degr.* 30 *min.* (2) the Angle of the Poles Elevation M C V 51 *deg.* 28 *min.* to find his Altitude C M; I ſay,

This Rule will hold by the Artificial Lines of Signs and Tangents.

As the Sign of the Angle of Latit. 51 *d.* 28 *m.* U C M 989334
is to the Sign of the Declin. 20 *degr.* 30 *min.* U M 954432
So is the *Radius* 90 *degr.* ——— 10

to the Sign of the Altitude 26 *deg.* 37 *min.* C M — 965098

Prob. X.

PROBL. X.

The Elevation of the Pole, *and Declination of the* Sun *being given, to find the Suns Altitude at the Hour of Six.*

TAke the neareſt diſtance from S to the Horizon C L, and apply it to the Line of Signs, ſheweth the Altitude to be 15 *degr.* 54 *min.* or the ſame taken of the Concave-Sphere, and meaſured on the Line of ½ Tangents, ſheweth the ſame; and ſo much is his Depreſſion under the Horizon at Six, when he hath South-Declination 20 *degr.* 30 *min.*

In the Concave-Sphere, you may ſee all the Triangles plain, and we have known in this Triangle Z S N, (1.) The Complement of the Latitude Z N 38 *degr.* 32 *m.* (2.) the Complement of the Suns Declination N S 69 *degr.* 30 *min.* to find the *Hypotenaſe* Z S; therefore I ſay,

As the *Radius* 90 *degr.* is in Proportion ——— 10
To the Co-Sign of 69 *degr.* 30 *min.* N S ——— 954432
ſo is the Co-Sign of 38 *degr.* 32 *min.* Z N ——— 989334
To the Sign of the Altitude 74 *degr.* 6 *min.* S 00 ——— 943766

Whoſe Sign is 15 *degr.* 54 *min.* is the Suns Altitude at the hour of Six, when he is 1 *degr.* 18 *m.* of ♈ in Latitude 51 *deg.* 28 *m.* Extend the *Compaſſes* from 90 *degr.* to 20 d. 30′, the ſame extent will reach from the Latitude 51 *deg.* 28 *min.* to 15 *deg.* 54 *m.* as before.

PROBL. XI.

Having the Latitude of the Place, and the Declination of the Sun given; to find the Suns Azimuth *at the Hour of Six.*

THis is repreſented in the Convex-Sphere by V Z in the Parallel of Altitude of the Sun V S B; Prick V B from C to W, and with the diſtance V S draw the Arch upon W at *b*, and lay the Ruler juſt touching the ſaid Arch, curs the Circle in Y; the diſtance H Y meaſured on the Chords, ſheweth the *Azimuth*, or the diſtance G oo, on the Concave-Sphere, applyed only to the Line of ½ Tangents, ſhews the *Azimuth* to be 13 *deg.* 07 *min.* and ſo much is the Sun to the Northwards of the Eaſt and Weſt of the hour of Six.

In the Right-Angled Spherical-Triangle Z N S of the general Diagram, we have known firſt, Z N, the Complement of the Latitude 38 *degr.* 32 *min.* (2.) N S the Complement of the Suns Declination 69 *degr.* 30 *min.* to find the *Azimuth* of the hour of Six, repreſented by the Angle N Z S.

I ſay,
As the *Radius* 90 is in proportion ——— 10
to the Compl. Sign of the Latitude 38 *deg.* 32′ Z N —— 979446
So is the Co-Tangent of N S 69 *deg.* 30 *min.* ——— 957273
to the Co-Tangent of the *Azimuth* N Z S 76 d. 53′ — 936719

Or extend the *Compaſſes* from the Co-Sign of the Latitude to the *Radius*; the ſame extent will reach from the Tangent of the Declination, to the *Azimuth* 76 *deg.* 53 *min.* as before; the Suns *Azimuth* from the North part of the Meridian in the Latitude of 51 *degr.* 28 *min.* and Declination 20 *degr.* 30 North, (13 *degr.* 07 *min* is from the Weſt.)

Prob. XII.

Having the Latitude of the Place of the Suns Declination, and his diſtance from the Meridian being given, to find the Suns Altitude at any Time aſſigned.

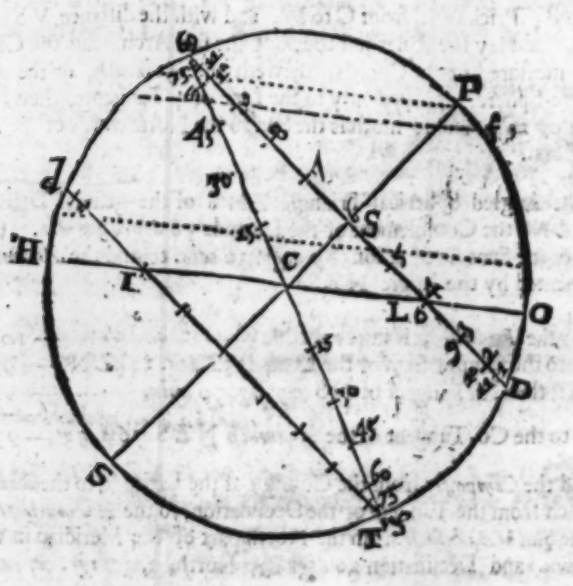
BY this Caſe may be found the Suns Altitude on all hours, and the diſtance of Places, in the Arch of a great Circle; for the Suns Altitude on all hours thereby is meant, that if the hour of the Day, the Declination and Latitude be given, the Suns Altitude proper to the hour, or his Depreſſion may be found.

Take the Chord of 60 *degr.* and deſcribe the Arch HTPOD, draw the Horizontal-Line HCO, and from O to P prick of the Chord of the Latitude 51 *degr.* 28 *min.* and from P to T and D ſet of the Complement of the Suns greateſt Declination, 66 *degr.* 29 *min.* and draw the Parallel of Declination TD, and the *Axis* CSP, or the Meridian of the hour of Six; then draw the *Radius* TC, which is the Ecliptick-Line, and take off the Line of Signs, and prick

down, 15 30 45 60 75 *degr.* for the Hours of 1 2 3 4 5 from 6 before it, and after it.

Then take the neareſt diſtance from 15 *degr.* to CS, the Meridian of the hour of Six, or *Axis*, and prick it from S to 5 and 7; and likewiſe take the neareſt diſtance fro 30 to CS, and lay it from S to 8 and 4; and in like manner do with the reſt, then will the neareſt diſtance from 4 5 6 7 8 9 10 11 to the Horizontal-Line HCO be the Signs of their reſpected Altitude;

ſo the Altitude —	4 5	In Summer will be	1 *deg.* 34 *min.* 9 30
for the hours —	6		18 12



And

And ſo much is the Suns Depreſſion under the Horizon at the hours of 8, 7, and 6 in Winter; as you may ſoon trie by the ſame Diviſion on the Parallel of the Suns greateſt Declination Southward DST

The Summer Alt. for the *h.* of	8	are	27 : 23
	9		36 : 42
	10		45 : 42
	11		53 : 45
			59 : 42

And the Winter Altitude for

the Hours of	9	are	5 *d.* 13
	10		10 : 28
	11		13 : 48

And ſo much is the Sun depreſt under the Horizon in Summer at the hours of 3, 2, 1, from Mid-night, as you may ſoon find it by the neareſt diſtance from 9, 10, 11, in the Line L D to the Line L O; if you apply that diſtance to the Line of Signs, you may draw the Parallel of Altitude through each hour, as the Example is through 9 *ho. e f*, and meaſure H *e*, or O *f* on the Line of Chords, and it is 45 *degr.* 42 *min.* the Suns Altitude at 9 a clock the 11 of *June.*

2. But admit the Latitude were 51 *deg.* 28 *min.* and his Declination 00 *deg.* 00 *m.* and ſuppoſe, for Example, ſeek his diſtance from the Meridian is 2 *ho.* 44 *min.* or 41 *deg.* 00 and the Sun upon the Equinoctial the 11 of *March*, and 13 of *September.*

Upon the Equinoctial at K is the Sun repreſented the 11 of *March*, or 13 of *September*, and diſtance from the Meridian 2 *ho.* 44, or 41 *degr.* 00 *min.* If in the Convex-Sphere you lay S ☉, from C to K the Right-Aſcenſion 59 *deg.* 9 *min.* and through K you draw a Parallel to the Horizon, as *d* M, it will cut the Meridian in *d*, and meaſure the diſtance H *d* on the Line of Chords, and it is 28 *degr.* 03 *min.* the Suns Altitude required, or the neareſt diſtance from K to the Horizon-Line H C O applyed to the Line of Signs, would have ſhewed the ſame. In the Concave-Sphere, if you take the diſtance C K, and draw a ſmall Arch at *r*; and take the neareſt diſtance to the Azimuth-Line of Eaſt and Weſt Z C from K, and with that diſtance turn the other Foot over, and croſs the Arch at (*r*,) and through K and *r* draw a Circle of Altitude, it will cut the Limb in E and F meaſure H E, or O F on the Line of Chords, ſheweth the Altitude 28 *degr.* 03 *min.* as before.

In the Concave-Sphere, you may ſee the Triangle Z Æ K; and we have given firſt Æ Z the diſtance from the Zenith to the Equator, equal to the Latitude of the place, 51 *degr.* 28 *min.* Secondly, Æ K the Suns diſtance from the Meridian 41 *deg.* to find the Suns Altitude from K to the Horizon.

I ſay, as the *Radius* 90 *deg.* ——— 10
is to the Co-Sign of the Suns diſtance from the Merid. 42 *d.* 0′ Æ K — 987777
So is the Co-Sign of the diſtance from the Equ. to the Zen. 51 *d.* 28 *m.* ÆZ 979446
to the Co Sign of Z K 61 *degr.* 53 *min.* ——— 967223

Whoſe Complement is the Altitude K *p* 28 *deg.* 03 *min.* which was required; you may in your practice draw a particular Figure for the Queſtion, and ſhew every Triangle by it ſelf, by the Line of Chords, and half Tangents.

Secondly, when the Sun is in North Signs, ♈ ♉ ♊ ♋ ♌ ♍.

Let it be required to find the Suns Altitude at 10 a clock and 2 *m.* paſt before Noon, when the Sun is in entrance of *Gemini*, in Latitude 51 *degr.* 28 *min.*

First,

First, By the Convex-Sphere, the neareſt diſtance taken from the Suns place, to the Horizon H C, applyed to the Line of Signs, ſheweth 51 *degr.* 12 *min.* the Suns Altitude required; Or to find his diſtance from the Meridian, take S T, and prick it from C to X; then with the diſtance S ⊕ on X as a Centre, draw the touch of an Arch at K, a Ruler laid over the Centre, over the outward edge of the Arch, cuts the Arch of the outward Meridian in (*n*;) then meaſure O *n* on the Line of Chords, and it is 60 *deg.* 2 *min.* S ⊕, whoſe Complement is 29 *deg.* 58 *min.* the Suns diſtance from the Meridian O T; Wherefore in the Triangle N Z ⊕, we have known, (1,) Z N the Complement of the Latitude 38 *deg.* 32 *min.* (2,) N ⊕, the Complement of the Suns Declination 69 *degr.* 30 *min.* (3,) the comprehended Angle Z N ⊕, the diſtance of the Sun from the Meridian 29 *deg.* 58 *min.* to find Z ⊕, and hereby the Suns Altitude 92 ⊕, I ſay,

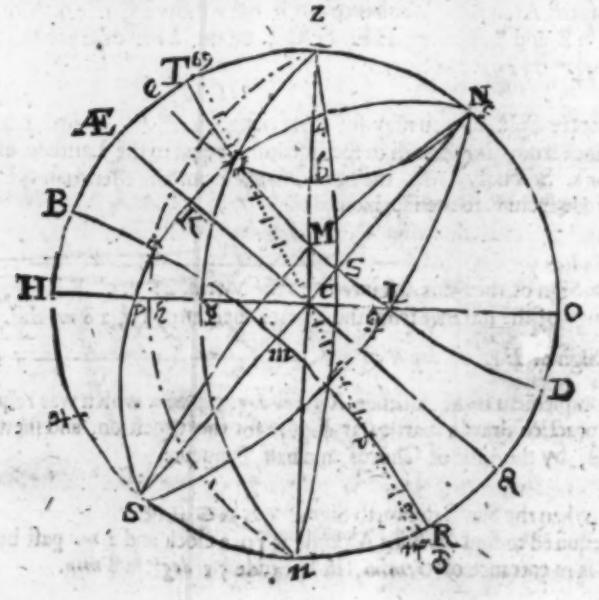
As the *Radius* 90 ——	10
is to the Co Tangent of the Latitude 51 *deg.* 28 *min.* N Z ——	990112
So is the Co-Sign of the Angle from the Meridian 29 *deg.* 58 *m.* Z N ⊕	993767
to the Tangent of the fourth Ark 34 *deg.* 36 *min.* N *q* ——	983879

From the Complement of the Suns Declination N ✱ 69 *deg.* 30 *min.* Subſtract N *q* 34 *deg.* 36 *min.* there remains 34 *deg.* 54 *min.*

As the Co-Sign of the fourth Ark. 34 *deg.* 36 *min.* N *q* ——	991547
is to the Compl. Sign of the Latitude 38 *deg.* 32 *min.* Z N ——	989334
So is the Co-Sign of the fifth Ark 34 *deg.* 54 *min.* *q* ⊕ ——	991389
	1980723
to the Co-Sign of Z ⊕ 38 *deg.* 48 *min.* ——	989176

Whoſe Sign is 51 *deg.* 12 *min.* ☉ the Suns Altitude above the Horizon at 10 a clock, and 02 *m.* paſt, and 1 a clock 58 *min.* paſt in the Afternoon, when he is in 1 *deg.* 18 *m.* of ♊ in Latitude of 51 *deg.* 28 *min.* North.

Now if you follow the Rules before-going, you may find the Suns Altitude by the Line of Chords, and half-Tangents by this Figure to be the ſame.



Suppoſe

Suppose the Sun in the Southern Signs ♎♏♐♑♒♓ in the opposite Point to the former, having South-Declination 20 *degr.* 30 *min.* and be also distant from the Meridian 29 *d.* 58 *m.* take the Declination 20 *deg.* 30 *min.* and prick it from Æ to B, and Q to R in both the Spheres, and draw the straight Line in the Convex-Sphere B M R, and take from the Suns place in the opposite Sign in the Parallel of Declination, his distance from the Meridian Y R, and prick it on the other side of the Parallel from B to ☉, and the nearest distance to the Horizon-Line H C, applyed to the Line of Signs, shews the Altitude to be 13 *d.* 23 *m.* and in the Concave-Sphere take of the Line of half-Tangents, the Declination 20 *degr.* 30 *min.* and lay it from the Centre C to M, and the *Axis* C S continued; take the Complement of the Declination of the Line of Secants, and place it from C on the continued Line or *Axis*, and that will be the Centre of the Parallel of Declination; or if you take the like Complement 69 *degr.* 30 *min.* of the Line of Tangents, and put it from M on the *Axis*, it will be the Centre of the Parallel of Declination; therefore draw it B M R, and it will cut the Meridian in ⊕, the place where the Sun is.

Now to find the Suns Altitude or Ark (Z ☉) or Z ⊕; therefore to find how much it is; you must find the Pole of the Circle N ⊕ Z, which is done after this manner.

Lay a Ruler from Z to ♄, and it will cut the Circle in ♑; then take 90 *deg.* and prick it from ♑ to ♋, then lay a Ruler over from Z to ♋, and it shall cut the Horizon in ♀, which Point ♀ is the Pole of the Circle Z ♄ *n*.

To measure the Ark Z ⊕, you must lay a Ruler upon ♀ and ⊕, which will cut the outward Circle in the Point X, so shall X Z measured on the Line of Chords, give you the quantity of *d.* contained in the Arch X Z, which will be 76 *d.* 37′ equal to the Complement of the Suns Altitude. I have been the larger in this precept, that it may be a Rule of Direction, to shew how the Ark of any great Circle of the Sphere, the sides of all Spherical Triangles being such, may be measured whatsoever, by his operation in the Concave-Sphere.

Observe the Figure we have given in the Oblique-Angled Triangle Z N ⊕. 1. N Z as before, the complement of the Latitude 38 *deg.* 32 *min.* 2. N ⊕ 110 *deg.* 30 *min.* the same distance from the North-Pole. 3. the Angle Z N ⊕ 29 *deg.* 58′ to find the Altitude ♄ ⊕.

As the *Radius* 90 —— 10
is to the Tangent of N Z 38 *deg.* 32 *min.* —— 990112
So is the Co-Sign of the Angle, Z N ⊕ 29 *deg.* 58′ —— 993767

to the Tangent of N ♀ 34 *deg.* 36 *min.* 4 Ark, as before, —— 983879

From the Ark N ⊕ 110 *deg.* 30 *min.* Substract the Arch N ♀ 34 *deg.* 36 *min.* and there remains 75 *deg.* 54 *min.*

As the Co-Sign of N ♀ 34 *deg.* 36 *min.* —— 991547
is to the Co-Sign of Z N 38 *deg.* 32 *min.* —— 989334
So is the Co-Sign of the fifth Ark ♀ ⊕ 75 *deg.* 54 *min.* —— 938670

1928004

to the Co-Sign of Z ⊕ 76 *deg.* 37 *min.* —— 936457

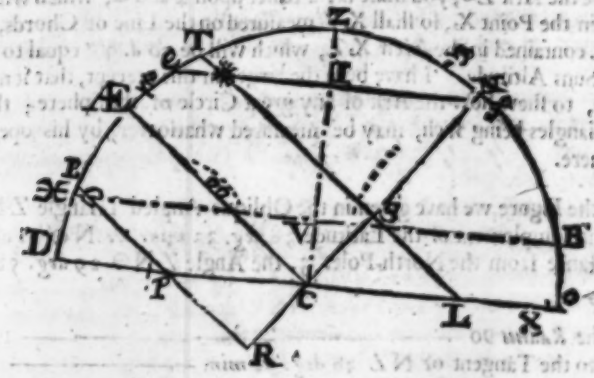
Now the Complement of Z ⊕, is ⊕ ♄ 13 *deg.* 23 *min.* which is the Suns Altitude required.

PROBL.

Prob. XIII.

The Suns Altitude, and his Distance from the Meridian, and Declination being given; to find his Azimuth.

DEmonstrate the Question by the Line of Signs and Chords, with 60 *degr.* draw the Semi-Circle, draw the Horizon-Line HO, draw the Parallel of Altitude *e f*, and of ☉B Parallel to the Horizon; then draw the *Axis* CN, and the Equinoctial CÆ at Right-Angles or 90 *degrees* from N, as NÆ; then draw the Parallel of Declination TL and (BR) by the Line of Chords, and Signs; then take the extent IE, and set from C to P, and upon P with the extent I ☉, draw the Arch (oo) a Ruler laid from C, just touching that Arch, cuts the Limb (♌) the Arch H ♌ measured on the Line of Chords, is 41 *degr.* 42 *min.* and so much is the Sun to the Southward of the East and West, the Complement is 48 *deg.* 18 *min.* and so much is the Suns Azimuth from the South part of the Meridian Westward. Now by the Concave-Sphere, if you find the Centre of the Azimuth-Circle on the Horizontal-Line at ☉, and draw the Circle from Z through ☉ N; measure the distance C☿ on the Line of half-Tangents, and it will be the Suns Azimuth from the East and West, as before, 41 *deg.* 42 *min.* (Complement 48 *deg.* 18 *min.* from the South.)



In the Oblique Spherical-Triangle ZN☉, we have known. 1. Z☉ the Complement of the Suns Altitude 38 *deg.* 48 *min.* 2. The Angle ZN☉ 29 *deg.* 58 *m.* the Suns distance from the Meridian. 3. The Complement of the Suns Declination N☉ 69 *deg.* 30 *m.*

Now I work thus;

As the Complement-sign of the Altitude 38 *degr.* 48 *min.* Z☉ —— 979699
is to the Sign of the Angle from the Merid. 29 *deg.* 58 *m.* ZN☉ — 969859
So is the Compl. Sign of the Declination 69 *deg.* 30′ N☉ —— 997158
1967011
to the Sign of the Suns Azimuth NZ☉ 48 *deg.* 18 *min.* —— 987312

Now admit the Altitude were 13 *degr.* 23 *min.* his distance from the Meridian 29 *deg.* 58′, and his Declination South 20 *deg.* 30′.

Set VY from ☾ to ♍, and with V☉ draw the Arch at ♂.

By the foregoing Rules, you will find the Arch H♈, measured on the Line of Chords 61 *deg.* 15 *min.* the Suns Azimuth from the East and West, whose Complement is 28 *deg.* 45 *min.* the Azimuth from the South part of the Meridian.

Or

Or on the Concave-Sphere draw the Azimuth Circle Z ⊕ ♄ N, and measure on the Horizontal-Line C ♄, applyed to the Line of half-Tangents, is 61 *deg.* 15′ as before, and the Azimuth 28 *deg.* 45 *min.* H ♄ from the South part of the Meridian; and 251 *deg.* 15 *min.* his Azimuth from the North part of the Meridian O ♄.

Observe the general Diagram of the Concave-Sphere, you have in the Oblique-Angled Spherical Triangle R N ⊕. 1. Z ⊕ the Complement of the Suns Altitude Z ⊕ 76 *deg.* 37′. 2. The Angle Z N ⊕ 29 *deg.* 58 *min.* his distance from the Meridian. 3. N ⊕ 110 *deg.* 30′, the Complement of the Suns Declination. The Rule is to find the Azimuth,

As the Complement-Sign of the Altitude Z ⊕ 76 *deg.* 37 —— 998804

is to the Sign of the Angle from the Merid. Z N ⊕ 29 *d.* 58 *m.* 969853
So is the Complement-Sign of the Declination N ⊕ 69 *d.* 30 *m.* - 993158

1967011

to the Sign of the Suns Azimuth N Z ⊕ 28 *degr.* 45 *min.* —— 968207

PROBL. XIV.

The Poles Elevation, with the Suns Altitude and Declination given; to find the Suns Azimuth.

FIrst, draw a Diagram by the Rules beforegoing in the Convex-Sphere, that is, the Elevation of the Pole O N 51 *deg.* 28 *m.* the Suns parallel of Altitude ♈ V 13 *d.* 23 *m.* and the parallel of the Suns Declination 20 *degr.* 30 *min.* B R; then take ♈ V, the parallel of Altitude, and prick ⊕ from C to 90; then take the distance V ⊕, and on ⊕ as a Centre, draw the Arch at (ρ) a Ruler laid over C, and the outside of (ρ) shall cut the Arch in (*n*,) then measure the distance (H W,) and the Line of Chords 41 *deg.* 15 *min.* as before.

Or draw the Concave-Sphere, and the Axis or Elevation of the Pole O N, and likewise prick from H and O on both sides the Parallel of the Suns Altitude ♈ V 13 *deg.* 23 *min.* and take the same number of the Line of half-Tangents, and prick it on C Z, the Prime Vertical Line of East and West from C upwards to (*v*,) and draw the parallel of Altitude, ♈ *v*, whose Centre will be upon the Vertical C Z continued or found, by taking the Complement of the Altitude 76 *deg.* 37 *min.* of the Line of Secants, and prick it from C on the Vertical-Line continued, and that is the Centre; draw ♈ as (♈*v*) thence draw the Parallel of Declination 20 *deg.* 30 *min.* by the former direction from Æ to B, and from Q to R, and take 20 *deg.* 30 *min.* of the Line of half-Tangents, and prick it from C on the Axis to (*m*,) and draw B ⊕ M R the Parallel, whose Centre is found upon the Axis continued, as before, by the Complement Secant of the Declination 69 *deg.* 30 *min.*

Then where the Parallel of Altitude and Declination cross each other, which is at ⊕, there is the Sun at that time; therefore draw the Azimuth-Circle, as before (12 Probl. directed,) from Z through ⊕ to N, and it will cut the Horizon in ♄, then measure C ♄, and it is the Suns Azimuth from the East and West, which applyed to the Line of half-Tangents, shews 61 *deg.* 15 *min.* as before, whose Complement is 28 *deg.* 45 *min.* the Azimuth from the South; in like manner measure all Azimuths from the Prime Vertical on the Horizon.

By Calculation; First, consider the Declination of the Sun, whether it be towards the North or South, so have you his distance from the Poles; then add this distance, the Complement of his Altitude, and the Complement of your Latitude all three together, and from half the sum Substract the distance from the Pole or Complement of his Declination, and note the difference.

Look well and observe the general Diagram in the Oblique-angled Triangle. Z⊕N the Complement of the Suns Altitude is Z⊕ 76 *deg.* 37 *min.* 2. The Complement of the Suns Declination is N⊕ 69 *deg.* 30 *min.* and the Complement of the Latitude Z N 38 *deg.* 32 *min.* which known, you may frame your operation, thus.

Decl. South 20 *d.* 30 *m.* } The distance from the Pole 110 *deg.* 30 *min.*
Suns Altit. 13 *d.* 23 *m.* } Complement, or Sign is 76 : 37, Z⊕ 998804
Latit. North 51 *d.* 28 *m.* } Complement, or Sign of 38 : 32, Z N 979446
37 *deg.* 18 *m.* } (4) Sign, or sum is —— 225 : 39, 1978250

all

The Sign of 67 *deg.* 21', or half sum of (3) 112 : 49 996461
So is the Sign of 2 *deg.* 19 *min.* or the difference 2 : 19 860662
Add the Radius (2) 2000000

From this Sum Substract 1978250 the fourth Sign 2857123
Take the half with the Radius (it is the 7th. Sign) 1878873
The half doth give the Mean-proportional Sign 14 *degr.* 22 *min.* 939439

And the double of 14 *degr.* 22 *min.* is 28 *degr.* 44 *min.* the Azimuth of the Sun from the South part of the Meridian; and it taken from 180 *degr.* 00 *min.* leaves 151 *degr.* 15 *min.* the Suns Azimuth from the North part of the Meridian, as before.

An Example for North Declination answerable to the first in (13 *Probl.*)

By the former Rules, you may find the Azimuth in each Sphere by Instrument. The Suns Declination North 20 *degr.* 30 *min.* his Altitude 51 *deg.* 12 *min.* the Latitude 51 *degr.* 28 *min.*.

Observe the Diagram in the Oblique-Triangle Z⊕N the Complement of the Suns Altitude Z⊕ 38 *deg.* 48 *min.* the Complement of the Suns Declination, N⊕ 69 *deg.* 30 *min.* the Complement of the Poles Elevation Z N 38 *deg.* 32 *min.* which known, the operation may be thus framed.

Suns Decl. North 20 *d.* 30 *m.* Compl. 69 *d.* 30' As the Radius
Altitude 51 : 12 Compl. 38 : 48 : 979699 is to the Co-Sign of Alt.
Latitude 51 : 28 Compl. 38 : 32 : 979446 so is the Co-Sign of Lat.

The Sum 146 : 50 : 1959145 to a fourth Sign 22 *d.* 59'

The ½ Sum. 73 : 25 : 998154 as 4 S. is to the S. of ½ sum
The difference 3 : 55 : 883445 so is the Sign of the differ.
Add the Base 69 *deg.* 30 N⊕ (2) 2000000

3881599
The half of it 1922454 to 2 7th. Sign 9 *d.* 39 *m.*
So is the Co-Sign 24 *deg.* 09 *min.* 961227

The double of it is 48 *deg.* 18 *min.* the Suns Azimuth from the South part of the Meridian, as before found, or 131 *deg.* 42 *min.* from the North part of the Meridian.

I have set down these two Examples thus particularly, to shew the agreement with the former two; this note, that generally in all Spherical-Triangles where three sides are known, and an Angle required, make that side which is opposite to the Angle required, to be the Base, and gather the Sum, the half Sum, and the difference, as before.

Having these means to find the Suns Azimuth, we may compare it with the Magnetical Azimuth, and so find the variation.

As for Example.

Admit the Magnetical Azimuth by the Needle, is —— 59 *deg.* 33'
And the Suns Azimuth found, as before, is —— 48 —— 18

The Variation is — the difference West —— 11 *deg.* 15

So the Magnetical Azimuth being more than the true Azimuth by 11 *deg.* 15 *min.* which is one Point of the Compass, therefore it shews the Variation to be one Point, or 11 *deg.* 15 *min.* Westerly.

And suppose the Course by the Compass be East 8 Points from the North or South, or 90 *degrees*; and let the Variation be 11 *deg.* 15 *min.* to the Westward.

I demand the true Rumb;

Mr. *Borough* observed in 1580 *d.* 11 *deg.* 15 *min.* Variation Easterly in Line, House, Fields.

The Magnetical Rumb —— 90 *d.* 00 *m.*
Substract the Variation Westerly — 11 *d.* 15
there remains the true Rumb NE 78 *d.* 45

Mr. *Gunter* 1662 found 6 *deg.* 15'

So that if the Variation be Westerly, you may concieve by looking upon the North-Point; by the Variation one Point, that it being Westerly, it is always accounted to the left hand, so the North-Point, is one Point to the right hand of his true place; and you must Sail N by W, to make good a North way, and W by S to be a good West, and S by E to be a direct South, and E by N to make good an East Course, which will make an Angle with the Meridian of 78 *deg.* 45 *min.*

2 Example.

But suppose the Magnetical Azimuth by the Needle had been —— 37 *d.* 03'
And the Suns Azimuth found, as before, to be —— 48 —— 18

Substract the lesser out of the greater, the difference NE —— 11 *d.* 15

And in regard the Magnetical Azimuth is less than the true Azimuth by 11 *deg.* 15 *min.* therefore the difference and variation is Easterly one Point, which is 11 *deg.* 15 *min.* and consequently all the Points, stand 11 *deg.* 15 *min.* or one Point to the left hand out of their true Places; and therefore, to make good a North Course, you must Sail by your Compass N by E; and an East Course, Sail E by South, and South Sail S by W; and to make good a West Course, Sail W by N; and so it is to be understood of all other Courses or Points; for in this Example, the true Course makes an Angle with the Meridian of 48 *deg.* 18 *min.*

The Year 1666 at *Bristol*, in *Rownam* Meadows, My self and Mr. *Philip Stainard*, and some other friends Masters of Ships, took with us a *Quadrant* described in the 16 Chapter of the Second Book of 20 *Inches* Semi-diameter, and one Needle, and one Azimuth Compass, described in the First of the Fifth Book, the Needle about 9 *Inches* long, the Chard 8 *Inches*; and in the Afternoon we made these Observations following.

Declin. 23 *d.* 30' dist. 66 *d.* 30
Altitude 44 : 20 Com. 45 : 40
Latit. 51 *d.* 28 *m.* Com. 38 : 32

The Sum —— 150 42
The half Sum — 75 21
The differencce -- 8 : 51

As the Radius is in proportion —— 10
To the Co-Sign of the Latit. 38 *d.* 32' 970446
So is the Co-Sign of the Alt. 45 *d.* 40 985447
To the fourth Sign 26 *d.* 27 *m.* —— 964287

Add the Radius to the Sum,
Take the half is the Sign of half the Ark.

As the fourth Sign 26 *degr.* 27 *min.* —— 964893
is to the Sign of the half Sum 75 *d.* 21′ —— 998564
So is the Sign of the difference 8 *deg.* 51′ —— 918709 add
1917273 ſum

to the ſeventh Sign 19 *deg.* 31 *min.* (add Rad.) 1952380
the half is the Mean proportional Sign of 35: 19976190

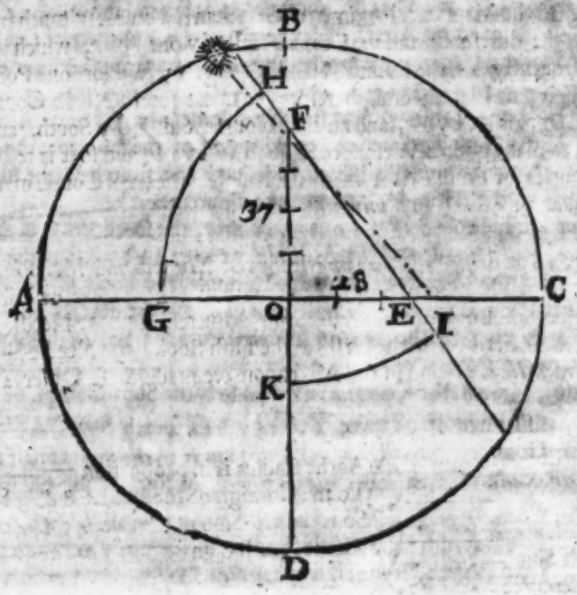
☉ Obſer. Altitude.		Magnetical Azimuth.		Suns true Azimuth.		Variation VVeſterly.	
Gr.	M.	Gr.	M.	Gr.	M.	Gr.	M.
44	20	72	00	70	38	01	22
39	30	80	00	78	24	01	36
31	50	90	00	88	26	1	34
27	42	95	00	93	36	1	24
23	20	103	00	101	23	1	23

Which doubled, is 70 *deg.* 38 *min.* the Suns Azimuth from the South part of the Meridian, or 54 *degr.* 41 *min.* the Complement of 35 *deg.* 19 *min.* doubled, is 109 *deg.* 22 *min.* the Suns Azimuth from the North part of the Meridian; and ſo of the reſt, as they are ſet down in this Table, *viz.* from the South part of the Meridian.

Prob. XV.

To find the Altitude of the Sun by the Shadow of a Gnomon *ſet Perpendicular to the* Horizon *by* Scale *and* Compaſſes; *as alſo by* Calculation.

VVIth your Compaſſes on a piece of Board, deſcribe the Circle ABCD, place it Horizontal with a *Gnomon* in the Centre O, croſs it with 2 Diameters; then turn the Board, until the ſhadow be upon one of the Diameters, at the end of the ſhadow make a Mark, as here at E; lay down alſo the length of the *Gnomon*-Pin or Wire from the Centre on the other Diameter from O to F, draw a right-Line from E to F, as EFH; then with the Chord of 60 *deg.* ſweep the Arch G H upon E as a Centre; apply the diſtonce G H the Arch to your Line of Chords, and that will give you the Altitude of the Sun required, as in this Example will be 52 *deg.* 53 *min.*



As the parts of the ſhadow 28 —— 144715
are to the parts of the *Gnomon* 37 —— 156820
So is the Radius 90 *deg.* —— 10000000
to the Tangent of 52 *deg.* 53 *min.* —— 10121105

So the Pin or *Gnomon* OF being 37 parts, and the ſhadow OE 28, ſuch equal parts, the Altitude will be found to be 52 *degr.* 53; or the *Gnomon* being 28, and the ſhadow 37 parts, the Altitude will be IK 37 *d.* 07 *m.* or the ſhadow being 83, the *Gnomon* or Staff 100, the Tangent of the Angle will be 50 *deg.* 18 *min.* 20″ the Altitude of the upper edge of the Sun or Angle HEG; from which, taking the Semi-diameter of the Sun 16 *m.* 27″, there remains 50 *d.* 1′ 59″ the true Altitude of the Centre of the Sun.

After this manner, if you obſerve the greateſt Meridian-Altitude of the Sun the 11 of *June*, and 10 of *December*, you ſhall by the difference of them find the diſtance of the Tropicks; the greateſt Declination of the Sun, and Elevation of the Equator, and Latitude of the Place.

As for Example.

At *London* the greateſt Meridian-Altitude of the Sun is 61 *deg.* 59″ 30‴; and the leaſt 14 *deg.* 56′ 30″.

The Suns greateſt Meridian-Altitude taken *June* 11, is	61 *d.* 59 : 30″
The Suns leaſt Meridian-Altitude taken *December* 10	14 : 56 : 30
The diſtance of the Tropicks, take the half of	47 : 03 : 00
And it is the Suns greateſt Declination, Subſtracted from the Alt.	23 : 31 : 30
Leaves the Elevation of the Equator,	38 : 28 : 0
Whoſe Complement is the Latitude of the Place,	51 : 32 : 0

PROB. XVI.

Having the Latitude of the Place, the Suns Declination, and the Suns Altitude; to find the Hour of the Day.

BY the Line of Chords and Signs, by the Convex-Sphere, ſet the extent SI, from C to X, and upon X as a Centre, with the extent S⊕, draw the Arch K, a Ruler laid from C juſt touching the Arch, finds the Point (*n*,) the Arch (*os*) meaſured on the Chords, ſheweth 61 *deg.* 10 *min.* the Suns diſtance from the hour of Six, *viz.* 4 *ho.* and almoſt one *min.*

The Rule is by the Tables; Add the Complement of the Suns Altitude, and the Complement of the Suns Declination, or Diſtance of the Sun from the Pole, and the Complement of your Latitude, all three together, and from half the ſum; Subſtract the Complement of the Altitude, and note the difference.

Thus in our Latitude of *Briſtol* 51 *deg.* 28 *min.* the Declination of the Sun, being 20 *deg.* 30 *min.* Northward, and the Altitude 51 *deg.* 12′. I find the Sun to be 29 *deg.* 50 *min.* from the Meridian, as by this Example.

Altitude of the Sun 51 *d.* 12, the Compl. 38 *d.* 48, As the Radius 90 10
Declination North 20 : 30 the diſtance from the Pole 63 30. to the Sign of the Suns diſtance from the Pole. —— 997158
Latitude North 51 : 28 the Compl. is 38 : 32 ſo is the Sign Compl. of Lat. 979414
The ſum of all three 146 : 50 to a fourth Sign —— 976572
The half Sum —— 73 : 25 as the 4 Sign is to the Sign of half ſum 998154
The difference —— 34 : 37 ſo is the Sign of the difference 975441
1973595
To a ſeaventh Sign add the Radius —— 1997023
Take the half, is the Sign of 14 *deg.* 55 *min.* —— 998511

The

The Mean Proportional between this ſeventh Sign, and the Sign of 90; that is, add the Radius to the ſeventh Sign, and take the half, and it will be the Sign of the Complement of half the Hour from the Meridian, which in this Example is found to be 14 *deg.* 55 *min.* the double of that is 29 *deg.* 50 *min.* which converted into Hours, doth give almoſt two Hours, it wants but 40 Seconds.

PROBL. XVII.

Having the Azimuth of the Sun, the Altitude of the Sun, and the Declination; to find the Hour of the Day.

THus the Declination being 20 *deg.* 30', the Altitude 51 *deg.* 12 *min.* the Azimuth from the South, found by the 14 Problem, to be 48 *deg.* 18 *min.* I might find the time to be 29 *deg.* 58', that is, almoſt 2 Hours wanting 8 Seconds; ſo the difference is 32 Seconds; that is, by reaſon of the ſeveral Operations, which is near enough for the Mariners uſe.

As the Co-Sign of the Declination 69 *deg.* 30 *min.* ——	997158
is to the Sign of the Azimuth 48 *deg.* 18 *min.* ——	987311
So is the Co-Sign of the Altitude 38 *deg.* 48 *min.* ——	979699
to the Sign of the Hour 29 *deg.* 58 *min.* ——	1967010
	969852

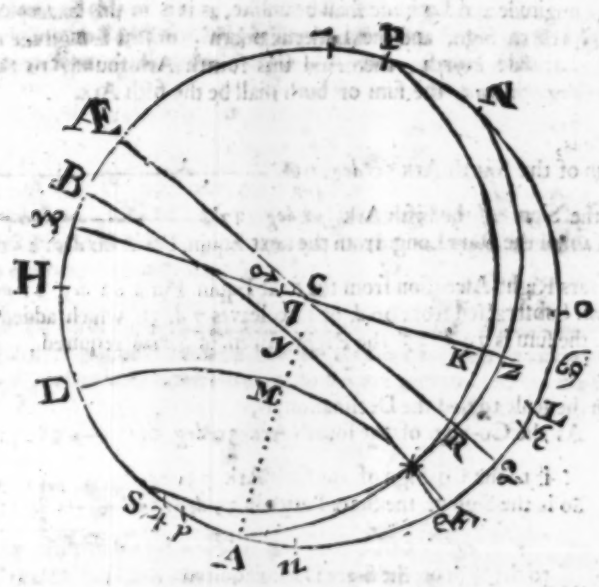
PROBL. XVIII.

How to find the Right-Aſcenſion of a Star, and the Declination of a Star; having the Longitude and Latitude of that Star given.

PRoject the Sphere Geometrically; that is, draw the great Meridian with a Chord of 60 *deg.* you may draw the Horizontal-Line H O, and Vertical Z N; then ſet the Latitude 51 *deg.* 28' from O to N, and draw Z Æ, and from H to S, and from N to Q, and draw the Equinoctial-Line Æ C Q, then take the diſtance of the Pole of the Ecliptick, from the Pole of the World 23 *deg.* 31 *min.* and prick it from N to P, from Æ to ♈, from S to A, and from Q to ♎; then draw the Ecliptick-Line ♈, C, ♎, on which you muſt put the Longitude or Diſtance of the Star, from the next Equinoctial-Point, as in this Example; The Star in the Mouth of the great Dog *Sirius*, his Longitude is found by the following Rules to be 9 *deg.* 32 *min.* of *Cancer*; and his Latitude is 39 *deg.* 30 *min.* South, a Star of the firſt Magnitude; take 9 *deg.* 32 *min.* out of 90 *deg.* the Remain is 80 *deg.* 28 *min.* the diſtance of the Star from the next Equinoctial Point C, prick that from C to K on the Ecliptick, and draw the Circle of Longitude P, K S, then prick the Latitude 39 *deg.* 30' from ♈ to D, and from ♎ to F by the Chords; then take the ſame number of the half-Tangents, and prick it from C to M, and draw the Circle of Latitude of the Star parallel to the Ecliptick, as D M F, and where this Parallel cuts the Circle of Longitude, as at ✳ that is, the place of the Star; then draw the Meridian-Circle from the North-Pole through ✳ the Interſection to the South-Pole, and it cuts the Equinoctial in R; meaſure C R on the Line of half-Tangents, and it gives the Right-Aſcenſion Complement to 180 *deg.* which is 82 *deg.* 21 *min.* the Complement is 97 *deg.* 39 *min.* the Right-Aſcenſion deſired.

Now to find the Declination of the Star; lay a Ruler over P and the Ecliptick, at K, and it will cut the Arch in L; take a Quadrant 90 *deg.* and prick it from L to P; lay a Ruler over *p* and P, and it will cut the Ecliptick in O; lay a Ruler over O, and ✳, and it cuts the Lamb in *e*; meaſure Q *e* on the Line of Chords, and it is 16 *deg.* 14 *m.* the Stars Declination required, By the *Concave-Sphere*; the *Convex-Sphere*, will not ſo conveniently ſhew the true Scituation and Place of the Stars as this; and therefore it is omitted.

By



By Calculation.

The Stars have little or no alteration in their Latitude; but in their Longitude they move forward about 1 *degr.* 25 *min.* in a hundred years, which is 85′.

By Noble *Tycho*, his Tables of Longitude and Latitude of the Stars, rectified by himself, to the beginning of the year 1601.

The Latitude of the most bright Star *Sirius* in the Mouth of the great Dog, is 39 *deg.* 30 *min.* and his Longitude is 8 *degr.* 35 *min.* 30″ of ♋; I desire the Stars true Longitude, or to be rectified for this present year 1667.

You must work by the Rule of Proportion, thus, if 100 give 85 *m.* what shall 66 the difference in years betwixt 1601, and 1667 give? Multiply, and Divide, and the Quotient will be 56 *m.* 6″ added to the Longitude found in the Tables of the Stars in the second Book on the back-side the Nocturnal, which 8 *deg.* 35 *min.* 30″ makes 9 *d.* 31′ 36″ of *Cancer*, the Longitude of the Star *Sirius* this year 1667; and so work to find the Longitude of any other Star in any other year, past, or to come.

Take 9 *deg.* 32′ the Longitude of the Star, out of 90 *deg.* there remains 80 *degr.* 28′, his distance from the next Equinoctial Point; which being known, the First Rule is,

As the Radius 90 ——— 10
is to the Sign of the Stars Longitude from the next Equ. Point 80 *d.* 28 CK 999396
So is the Co-Tangent of the Stars Latitude 39 *deg.* 30′ A ✱ ——— 1008389
to the Tangent of the fourth Ark 50 *deg.* 06 *min.* ——— 1007785

Compare this fourth Ark with the Arch of Distance betwixt the Poles of the Ecliptick, and the Poles of the World 23 *deg.* 31 *min.* if the Longitude and Latitude of the Star be alike, as in North Signs ♈ ♉ ♊ ♋ ♌ ♍, and the Latitude is on the North-side the Ecliptick; or if the Longitude be among the Southern Signs, as ♎ ♏ ♐ ♑ ♒ ♓, and the Latitude Southward; then shall the difference between the fourth Ark found, and the distance of the Poles 23 *deg.* 31′ be your fifth Ark.

But

But if the Longitude and Latitude ſhall be unlike, as it is in this Example; as the Longitude in a Northern Sign, and the Latitude South; or the Longitude in a Southern Sign, and the Latitude North; then Add this fourth Ark found, to the diſtance of both Poles 23 *deg.* 31 *min.* the ſum of both ſhall be the fifth Ark.

Then the Rule is,
As the Sign of the fourth Ark 50 *deg.* 06′ —— 988488
is to the Sign of the Fifth Ark 73 *deg.* 37′ —— 998199
So is the Tan. of the Stars Long. from the next Equin. Point 80 *deg.* 28 *m.* 4077484
to the Stars Right-Aſcenſion from the next Equin. Point 82 *deg.* 21 *m.* 2075683
82 *d.* 21 *m.* Subſtracted from 90 *d.* or 180 leaves 7 *d.* 39′ which added to 90 *d.* the ſum is 79 *d.* 39′ the Right-Aſcen. of *Sirius* required. — 1087195

Then the Rule to find the Declination, is,
As the Co-Sign of the fourth Ark 50 *deg.* 06′ —— 980716
is to the Co-Sign of the fifth Ark 73 *deg.* 37′ — 945034
So is the Sign of the Stars Latitude 39 *deg.* 30′ —— 980351
1925385
to the Sign of the Stars Decl. required 16 *d.* 14′ 944669

You have the proof of the Work by the foregoing Geometrical Rules; or you may take this by Calculation, if there be no former errour, the Proportion will hold.

As the Co-Sign of the Latitude 39 *deg.* 30 *min.* —— 988740
is to the Co-Sign of the Right-Aſcen. from the next Equ. Point 82 *d.* 21′ 912424
So is the Co-Sign of the Declination 16 *deg.* 14 *min.* —— 998233
1910657
to the Compl. Sign of Longit. from the next Equinoctial 80 *d.* 28 *m.* or Sign of the Longitude 9 *deg.* 32 *min.* as was at firſt given. — 921917

By theſe Rules and directions work, to find the Right-Aſcenſion, and Declination of any Star, which you deſire to know.

Probl. XIX.

Having the Declination, and Right-Aſcenſion of a Star; to find the Longitude and Latitude thereof.

IN the former Diagram of the 18th Problem, you have the Right-Aſcenſion of the Gliſtering-Star in the great Dog's Mouth called *Sirius*; C R 82 *d.* 21 *m.* take it off the Line of half-Tangents, and prick it from C to R; and you have alſo the Declination drawn B *y e*; then draw the Meridian-Circle from N, cutting the Point R, the Stars Right-Aſcenſion from the next Equinoctial Point, and Parallel of Declination in ✳ to S the South-Pole; then take the diſtance of the Poles of the World, and the Poles of the Ecliptick 23 *d.* 31′, and prick from N to P, and from Æ to ♈, and from S to A, and from Q to ♋, and draw ♈ C ♋ the Ecliptick-Line; then draw the Circle of Longitude through P, through the Interſection of the Parallel of Declination, and Meridian, which is the body of the Star to A, and it will cut the Ecliptick in K; meaſure C K on the Line of half-Tangents, and you have the Longitude of the Star from the next Equinoctial-Point 80 *deg.* 28 *min.*

And

And to find the Latitude; if you lay a Ruler over P and K, it will cut the Limb in ♄, prick 90 *deg.* from ♄ to ♑, and lay a Ruler over P and ♑, and it will cut the Ecliptick in the Point ♂; lay a Ruler over ♂ and ✱, and it will cut the Limb in F; apply the distance ♋F, to the Line of Chords, and it will be 39 *deg.* 30′, the Latitude required.

In the Triangle ZRC, by Calculation, we have 1. the Angle ZCR, the distance of the Poles 23 *degr.* 31 *min.* 2. the side CR 82 *degr.* 21′, the Right-Ascension from the next Equinoctial-Point; then reason must guide you, as by these Rules, to find the Longiture and Latitude of a Star.

As the Radius 90 *deg.* ——— 10
is to the Tang. of the Angle ZCR 23 *d.* 31 *m.* the Poles distance - 963864
So is the Sign of Right-Ascension CR 82 *d.* 21′ from the next Point - 999611
to the Tangent of ZR 23 *deg.* 20 *min.* ——— 963475

Which 23 *degr.* 20′ add to the South-Declination 16 *degr.* 14 *min.* makes 39 *deg.* 34′, ZR; but if the Declination had been Northerly, you must have Substracted the Arch found out of it, and the Remain had been ZR; but if it had been more than the Declination, Substract it out of the Arch found, and the difference had been ZR; so with reason wave the Rule, as occasion requireth.

Then to find the Angle CZR, and the side CZ, the Rule is,

As the Sign of the fourth Ark ZR 23 *deg.* 20′ ——— 959778
is to the Sign of the Angle of distance of the Poles ZCR 23 *d.* 31′ — 960099
So is the Sign of Right-Ascen. from the next Equ. Point CR 82 *d.* 21 *m.* 999611
1959710
to the Sign of CZR 86 *deg.* 49 *min.* the fifth Ark ——— 999932

Then;
As the Sign of ZCR 23 *deg.* 31 *min.* ——— 960099
is to the Co-Sign of RC 23 *deg.* 20 *min.* — 959771
So is the Sign of CRZ 9 *degr.* Radius ——— 10
to the Sign of CZ 83 *degr.* 03 *min.* ——— 999679

Which Angle CZR 86 *deg.* 49′ is equal to the Angle ✱ZK.

Then to find the Latitude of the Star,

As the Sign of ✱KZ Radius 90 *degr.* ——— 10
is to the Sign of 39 *deg.* 34′ the 4 Ark and Declination R✱ — 980412
So is the Sign of ✱ZK 86 *deg.* 49 *min.* ——— 999932
to the Sign of the Latitude of the Star desired ✱K 39 *deg.* 30 *m.* 980344

And lastly, to find the Arch ZK, and by it consequently the Longitude CK.

As the Tangent of the Angle ZK✱ 86 *deg.* 49 *min.* ——— 1125479
is to the Radius 90 *deg.* ——— 10
So is the Tangent of Z✱ 39 *degr.* 34′ ——— 991713
to the Sign of ZK 2 *deg.* 35′ ——— 866234

Therefore, if you Subſtract 2 *degr.* 35 *min.* out of the Arch CZ 83 *deg.* 03 *min.* the Remain is 80 *degr.* 28 *min.* the true Longitude of the Gliſtering Star *Sirius* in the Mouth of the great Dog, from the next Equinoctial-Point at the time given.

But if the Meridian-Circle had cut the Ecliptick at K, and the Circle of Longitude at Z; then in ſuch caſes, add the Arch found ZK to CZ, and the ſum had been the true Longitude from the next Equinoctial-Point C; and ſo work with reaſon, to find the Longitude and Latitude of all other Stars, as by reaſon you did Subſtract ZK from CK; therefore the Sign was above a Quadrant, if you Subſtract his diſtance from the Vernal-Equinox 80 *deg.* 28 *min.* from 90 *d.* the Remain is 9 *deg.* 32′ of *Cancer*, the Sign and *deg.* the Star is in, as before.

Prob. XX.

Having the Meridian-Altitude of an unknown Star, and the diſtance thereof from a known Star; to find the Longitude and Latitude of the unknown Star.

IN the 16th Chapter of the ſecond Book of *Harmonicon Cœleſte*, Mr. *Vincent Wing* hath this Example, and Obſervation, made by the *Phœnix* of *Aſtronomy Tycho-Braghe* in the year 1577, which we will borrow for an Example; it being a uſeful Rule for all Ingenious Navigators, for by it they may find the Longitude and Latitude, and conſequently, by the foregoing Rules, the Right-Aſcenſion, and Declination of thoſe good Stars for their uſe, that are in the South Hemiſphere, *viz.* as they have been named by the *Portugals*; the South-Triangle, which Conſtellation hath 5 Stars, one of the Eaſtermoſt corner, which comes laſt to the Meridian of the ſecond Magnitude. The *Crane*, in which there is 13 Stars on the left Wing, and another on the right ſide the back of the ſecond Magnitude. The *Phœnix*, 15 *Stars*, the *Water-Serpent* hath 15 Stars. The *Dorado*, or Gilt-head-Fiſh, ſituate in the very Pole of the Ecliptick; and in that Conſtellation is 4 Stars. The *Chamelion*, with the *Flie*, in which is 13 Stars; The *Bird* of *Paradiſe*, in which is 12 Stars; the *Peacock*, in which is 15 Stars; one in the head of the ſecond Magnitude; the *Naked Indian*, in which is 12 Stars; and alſo the Bird *Taican*, or *Braſilian Pye*, in which Conſtellation is 7 Stars, two of them of the third Magnitude: Alſo two uſeful Stars for Navigators; in one Conſtellation, which are *Noah's Dove*, which containeth 11 Stars, of which there are 2 in the back of it, of the ſecond Magnitude, which they call the *Good Meſſengers*, or Bringers of good News, and thoſe in the right-Wing are conſecrated to the appeaſed Deity; and thoſe in the left to the retiring of the Waters, in the time of the Deluge; and they come to the Meridian about half an hour before the great Dog; and by the Globes are about 21 *degr.* 30′ diſtant, from the neareſt in the back; but I would have the Sea-men take him exact, as likewiſe a good Conſtellation called the *Crane Grus*, or the *Flamengo*, as the *Spaniards* call it; this Aſtenſine conſiſteth of 13 Stars, and hath 3 Stars of the ſecond Magnitude, that in the head is called the *Phanicopter Eye*, and the other are on his Back, and the other in his left Wing; Theſe Stars I would deſire thoſe Mariners that Sail to the Eaſt or Weſt-Indies; to take the Meridian-Altitude thereof, and their diſtance from any known Stars, and by it you ſhall have all the reſt; for many times I have been Sailing between the Tropicks, and for 12 days together have had no Meridian-Altitude of the Sun, by reaſon of cloſe and cloudy weather, which is bad for thoſe that are bound to ſmall Iſlands, and Cape-Lands; therefore to the Southward, as well as to the Northward; theſe Stars will ſtand them in great ſtead, and ſerve their turn, as well as the Sun, to find the Latitude thereof.

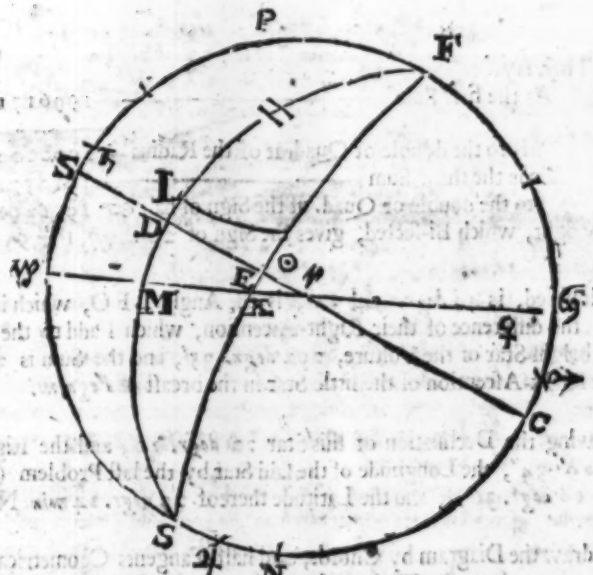
The Rule is thus; About the end of the Year 1577, *Tycho* obſerved the diſtance of the little Star in the breaſt of *Pegaſus* from the bright Star of the *Vulture*, to be exactly 45 *degrees* 31′, and by the Meridian-Altitude thereof, he found the Declination thus.

Tycho

Tycho observed at *Uraniburge* the Star in the breast of *Pegasus*, and found his Meridian-Altitude ——— 56 *d.* 32 *m.*
The Latitude of *Uraniburge* is 55 *d.* 54′ the Compl. 34 06 Substract the Altitude of the Equator.
The Declination is found to be ——— 22 : 26
To it add the Complement of 56 *deg.* 32′, which is 33 : 28
And the sum is the Latitude of *Uraniburge* —— 55 : 54 *m.*

So the Declination is found to be 22 deg. 26 min. North, which being given, the Longitude of the said Star is to be inquired.

Therefore in the Oblique-Angled Triangle (of this Diagram) F O L is known.



First,

The Complement of the Declination of the bright Star of the *Vulture* 82 *degrees* 8 *min.* FL.

Secondly,

FO, the Complement of the Declination of the Star in the Breast of *Pegasus* 67 *degr.* 34′.

Thirdly,

OL the distance of them 45 *degr.* 31′.

By this Rule the Angle at F, which is the difference of their Right-Ascension, will be found to be 44 *degr.* 54″, as will be here demonstrated.

The Co-Sign of Declination F L, is 82 *deg.* 08 *min.* — 999589
The Co-Sign of Declinat. F O, is 67 — 34 — 996582

The difference is — 14 — 34

(1.) The ſum is — 1996171
(2.) The Quadrat or (2) the Rad. — 2000000

The Baſe or diſtance of the Stars L O — 45 *d.* 31
The difference of their Declin. F L and F O 14 : 34

The Sum — 60 : 05
The difference — 30 : 57

The half of the Sum — 30 *d.* 02 30″ Sign — 969951
The half of the difference — 15 : 28 30 Sign — 942621

The (3) Sum is — 1912572

Then ſay,
As the firſt Sum — 1996171
is to the double or Quadrat of the Radius — 2000000
So is the third Sum — 1912572
to the double or Quad. of the Sign of half ♉ 1916401
The Angle ſought, which Bi-ſected, gives the Sign of 22 *d.* 27′ 17″ 958200

Which doubled, is 44 *degr.* 54′ 34″, is the Angle L F O, which is equal to the Arch D E, the difference of their Right-Aſcenſion, which I add to the Right-Aſcenſion of the bright Star of the Vulture, 292 *degr.* 35′, and the Sum is 337 *degr.* 29′ 34″, is the Right-Aſcention of the little Star in the breaſt of *Pegaſus*.

Then having the Declination of this Star 22 *degr.* 20′, and the Right-Aſcenſion 337 *degr.* 29′ 34″, the Longitude of the ſaid Star by the laſt Problem (19) will be found to be 18 *degr.* 36 ♓, and the Latitude thereof 29 *degr.* 24 *min.* North.

Now to draw the Diagram by Chords, and half-Tangents Geometrically, with the Chord of 60 *degr.* draw the Circle; then draw ♈, ♎, the Ecliptick 23 *degr.* 31′ ♑, S, and by C draw the Equator; then by the Parallel of Declination, and Right-Aſcenſion of the Vulture, will find L O; therefore if you put the difference of Aſcenſion from ♈ to E 22 *degr.* 30′ 20″, from the neareſt Equinoctial-Point, and draw the Meridian-Circle F E S, and it will cut the Parallel of Declination at O; draw through O, as P O N the Circle of Longitude, and meaſure ♈ X on the Line of half-Tangents, and it is 11 *degr.* 24 *min.* from the neareſt Vernal Equinox, Subſtracted from 30 *degr.* leaves 18 *degr.* 36′ of ♓ for the Stars Longitude; and as before directed, you may find the Latitude ♑ ♄ to be 29 *degr.* 24′.

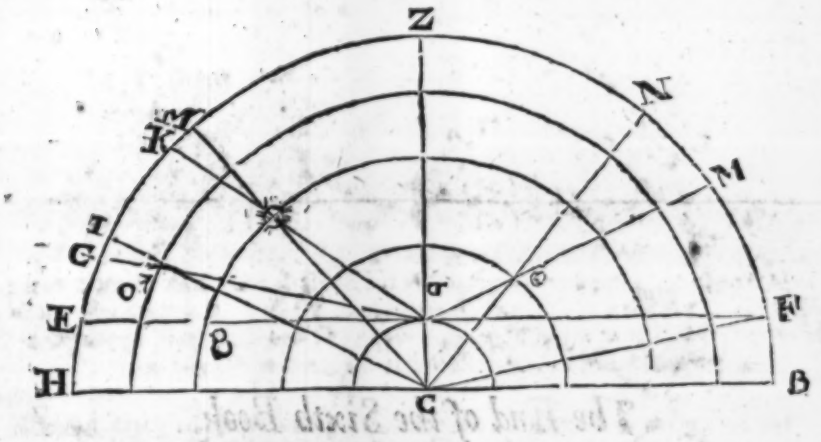
Probl: XXI.

PROBL. XXI.

To find the Parallax of Altitude of the Sun, Moon, or Stars.

THe true Altitude of the Sun, Moon, or Stars, ought to be obſerved in the Centre of the Earth, (if poſſible) whereto the Tables are conformed; but becauſe we dwell upon the Superficies of the Earth 4000 Miles neareſt, or 3983 Engliſh Miles from the Centre of the Earth; therefore, the Planets ſeem lower to us, than indeed they be; and therefore to find the true place of the ☉ ☾ ✳, you muſt draw a Right-Line from the Centre of the Earth, through the Centre of the Sun, Moon, or Stars; but the apparent viſible place is determined by a Line drawn from the Eye, through the Centre of the Star; therefore the Parallax of a Star is an Arch of a great Circle, paſſing by the Zenith, and the true place of the Star, the Arch of the ſame Circle intercepted between the true and apparent place.

A Figure or Scheme ſhewing what the Parallax, or diverſity of Aſpects is.



In this Figure, C denotes the Centre of the Earth.

D the Place or Superficies of the Earth, from whence the ☉ ☾ or ✳ is ſeen.

☾ ☉ and ♂, their Place in their Orbs.

C♂I, C☉M, C☾N. the Lines of their true Place.

D♂G, D☉K, D☾M, the Lines of their viſible or apparent Places.

Hence the Angle made by the Interſection of the ſaid two Lines through the Body of the Planet, is the Angle of Parallax, that is to ſay, in ♂ the Angle C♂D, which is equal to the Angle I♂G, in the ☉ the Angle of Parallax, is the Angle C☉D; and laſtly in the Moon it is the Angle C☾D, or N☾M, which is all one.

By this it is manifeſt, the nearer a Star is to the Horizon and Centre of the Earth, the greater is the Parallax; and hence it is, that the Orbit of the Moon being neareſt to the Earth, her Parallax is greateſt, and moſt perceptible, becauſe the Semi-Diameter of the Earth bears a ſenſible proportion to the Semi-Diameter of the Moons Orbit, though it be very little, or nothing at all in compariſon of the Orbs of ♄ ♃, and the fixed Stars, which is cauſed by the Interval and vaſt diſtance which is between them; but this laſt Problem hath no relation to the common uſe of Mariners, therefore I ſhall not inſiſt any further, but refer the Reader to *Harmonicon Coeleſte*, where there is a full diſcourſe, and Rules relating thereunto.

But

But these Astronomical Propositions as I know to be useful for Sea-men, I have here inserted; for the first and second will find the Suns Place and Declination, together with the 15 Probl. will find the Latitude.

The third, fourth fifth, and sixth will find the Suns Rising and Setting, as the 7, 8, 9, 10, 11, 13, 14, to find the Variation of the Compass, and the 12 to find the Suns Altitude at any time assigned, and the rest being very useful Rules of the Stars, by which you may have the Hour of the Day, and Night; for having the Latitude of the Place, with the Declination and Altitude of the Sun, or any Star, they may find the Hour of the Sun or Star from the Meridian by the 16 and 17 Problem; then comparing the Right-Ascension of the Sun, with the Right-Ascension of the Star, they may have the Hour of the Night in all these Propositions; I have been as plain and as brief, as the several Resolutions thereof would permit me; and I do wish the Practitioner as much delight in the Practice, as I have had in the Composing of it.

The End of the Sixth Book.

The Seventh Book.

THE Mariners Magazine,

OR,

STURMY'S Mathematical and Practical ARTS.

THE ART OF DIALLING BY THE Gnomical Scale,

AS ALSO BY

CALCULATION.

SHEWING

The Making of all ſorts of DIALS, both within Doors and without, upon any Walls, Cielings, or Floors, be they never ſo irregular, whereſoever the Direct or Reflected Beams of the Sun may come, for any *Latitude*.

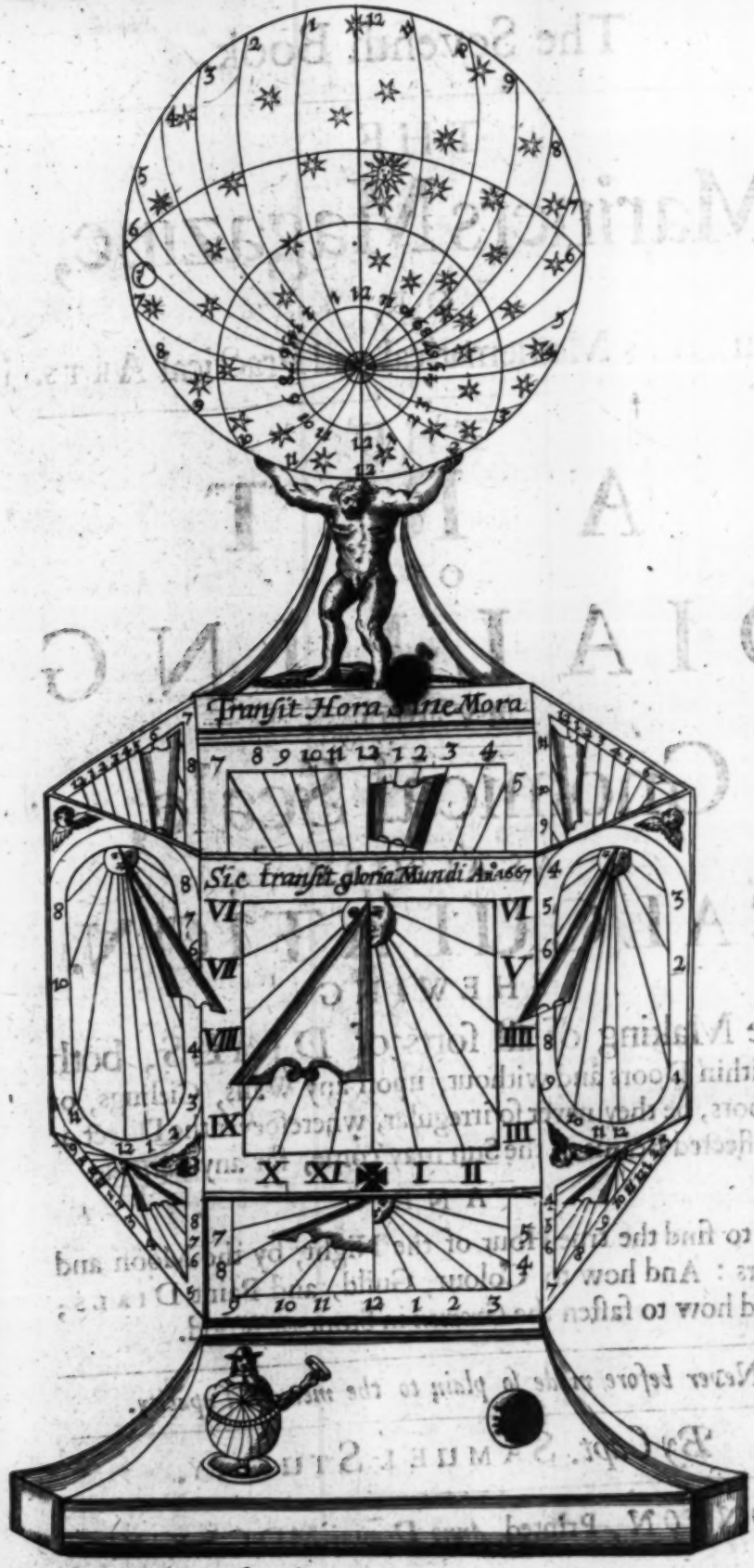
AND

How to find the true Hour of the Night, by the Moon and Stars: And how to Colour, Guild, and Paint DIALS; And how to faſten the *Gnomon* in Stone or Wood.

Never before made ſo plain to the meaneſt Capacity.

By Capt. SAMUEL STURMY.

LONDON, Printed *Anno Domini* MDCLXIX.



Horologium vitæ.

Latus ad occasum nunquam rediturus ad ortum
Vivo hodie, moriar cras, heri natus eram

To my much Honoured Friend

Iſaac Morgan Eſq;

Collector of his Majeſties Cuſtoms in the Port of *Briſtol.*

SIR,

NOt *to inform your Judgment in any thing concerning the Subject Matter of theſe my poor Labours (your Wiſdom and approved Knowledge in all Learning being ſo general, that I can add nothing unto it) but to inform the World how much I honour you and your Vertues, and by how many Obligations I ſtand engaged to you for the many ſignal Favours you have vouchſafed me ſince the time I came firſt into this Port, I dedicate this Part of my Book, as the proper Part of the fruits of my ſpare time, in twenty ſeven* Dials, *unto you preſented as an unworthy* New-years-gift; *and that* Dial-piece *being the Subject of the whole Art of* Dialling, *I will name the* Dials, *that I may charge you to Patronage no more than you had*; viz. *Eight* Verticals *and* Decliners, *Eight* Recliners *and* Incliners, *and Eight* Decliners, Recliners, *and* Incliners, *a* Globe *with two* Pole-Dials, *and one* Shadow-Dial, *made on a Piece of* Freez-ſtone, *as is ſeen in the Frontiſpiece the* Gnomon *or* Stile *faſtned by me, and likewiſe Painted and Guilded, which is well*

known by you and many others: And being desired by some Friends that saw my way, and this Piece of Dialling, *to Print it, by their importunity, according to the best of my judgment, I have so done; and if any way profitably, then according to mine own desire. As it is, I have made bold to make choice of you for the Patronage thereof, that it may gain the more Credit by your Protection; And if any shall be offended at this Work, my Device shall be a* Dial, *with this* Motto, ASPICIO UT ASPICIAR; *only to all Favourers of* ART *I am* direct, erect, plain, *as I am, Sir, to you, and desire to be,*

SIR,

Your humble and affectionate

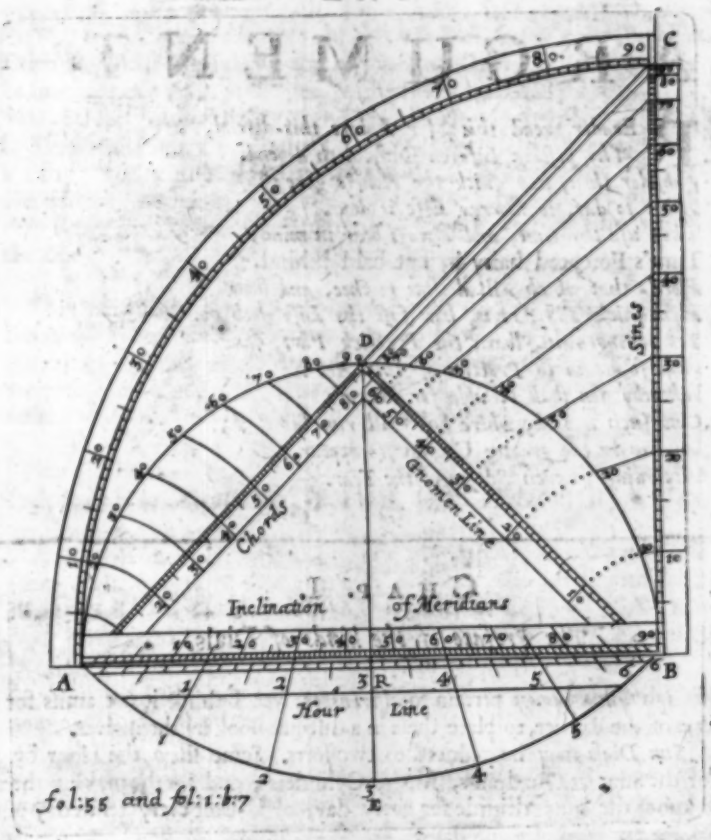
Servant to be commanded,

St. Georges the Pill,
the 29 Aug. 1667.

SAMUEL STURMY.

THE Art of Dialling.

The FUNDAMENTAL DIAGRAM *of the* DIALLING SCALE.



fol:55 and fol:1:b:7

THis *Diagram* of the *Geometrical Scale* I have described *Book* 2. *Chap.* 3. to which I refer you.

I ſhall only deſcribe the Lines on the Scale, *viz.*

There are ſix Scales or Lines on this Inſtrument.

1. A Scale or Line of Chords, A D, in Degrees.

2. A

2. A *Gnomon* Scale or Line, as B D, the uſe thereof you may ſee in *Chap.* 7. and ſo forward in *Degrees.*

3. A Scale or Line of ſix Hours, for drawing the Hour-lines in any Dial, divided into every 10 Minutes; the uſe you may read from *Chap.* 4. forward, as B E A.

4. A Scale of Inclination of Meridians, divided in Degrees as the *Diam.* B A; the uſe thereof is in *Chap.* 12. and ſo forward.

5. Upon the other ſide are two Lines or Scales, for the inlarging the Hour-Lines on any Plain: The greater Pole is marked with +; the leſſer is marked with —, called the leſſer Pole for diſtinction ſake; and theſe Lines are divided into every 10 Minutes, but may be by the Table into every 5 Minutes.

6. Theſe Scales or Lines are on the Mathematical Scale, with the reſt that are deſcribed *Book* 2. called *The Scale of Scales.*

THE ARGUMENT.

READER, read this; for I dare this defend,
Thy poſting Life on Dials *doth depend.*
Conſider thou, how quick the Hour's gone;
Alive to day, to morrow Life is done.
Then uſe thy time, and always bear in mind,
Time's Forehead hairy is, but bald behind.
Here's that which will decline to thee, and ſhow
How quick Time runs, how faſt thy Life doth go.
Yet be ingenious, learn the Practick Part,
And ſo attain to Practice of this Art:
Whereby you ſhall be able for to trace
Out ſuch a path, where Sol *ſhall run his Race;*
And make the greater Coſmus *to appear,*
According to each Seaſon of the Year.

CHAP. I.

The Preface of the kinds of Dials.

ALthough *Gnomoniques* pertain to *Aſtronomy*, yet I think it not amiſs for the eaſe of the Reader, to place theſe in a diſtinct Book by themſelves.

Sun-Dials may be reduced to two ſorts. Some ſhew the Hour by the Altitude of the Sun, as Quadrants, Rings, Cylinders; and for the making thereof, you muſt know the Suns Altitude for every day, or at leaſt every tenth day of the year, and for every hour of thoſe days.

The other ſort ſhew the hour by the ſhadow of a *Gnomon* or *Stile* paralled to the *Axis* of the World; and of that I treat chiefly in this Book. Theſe be all Projections of the Sphere, upon a Plane which lies parallel to ſome *Horizon* or other in the World. And if upon ſuch a Plane the *Meridians* only be projected, they ſhall ſuffice to ſhew the Hour, without projecting the other Circles, as the *Eeliptique*, the *Æquator* with his Parallels of Declination, the *Horizon* with his *Almicanters* and *Azimuths*, which are ſometimes drawn upon *Dials* more for Ornament than for Neceſſity.

CHAP.

CHAP. II.

Theorems premiſed.

FOr the better underſtanding of the Reaſons of *Dials*, theſe *Theorems* would be known.

I. That every Plane whereupon any *Dial* is drawn, is part of the Plane of a Great Circle of the Heaven, which Circle is an *Horizon* to ſome Country or other; That the Center of the *Dial*, repreſenteth the Center of the Earth and World; and the *Gnomon* which caſteth the Shade, repreſenteth the *Axis*, and ought to point directly to the two *Poles*.

II. That theſe *Dial* Planes are not Mathematically in the very Planes of Great Circles; for then they ſhould have their Centers in the Center of the Earth, from which they are removed almoſt 4000 miles; and yet we may ſay they lye in the Planes of Circles parallel to the firſt *Horizon*, becauſe the Semidiameter of the Earth beareth ſo ſmall proportion to the Suns Diſtance, that the whole Earth may be taken for one Point or Center, without any perceivable Error.

III. That as all Great Circles of the Sphere, ſo every *Dial* Plane hath his *Axis*, which is a ſtraight Line paſſing through the Center of the Plane, and making Right Angles with it; and at the end of the *Axis* be the two *Poles* of the Plane, whereof that above our *Horizon* is called the *Pole Zenith*, and the other the *Pole Nadir* of the *Dial*.

IV. That every Plane hath two Faces or Sides: and look what reſpect or ſituation the *North Pole* of the World hath to the one ſide, the ſame hath the *South Pole* to the other; and theſe two Sides will receive 24 Hours always: ſo that what one Side wanteth, the other Side ſhall have; and the one is deſcribed in all things as the other.

V. That as *Horizons*, ſo *Dial* Planes are with reſpect to the *Æquator* divided into firſt, *Parallel* or *Æquinoctial*; ſecondly, *Right*; thirdly, *Oblique* Planes.

VI. A *Parallel* or *Polar* Plane maketh no *Angles* with the *Æquator*, but lies in the Plane of it, or parallel to it; that is, hath the *Gnomon* erected on the Plane at Right Angles, as the *Axis* of the World is upon the Plane of the *Æquator*: becauſe the *Axis* and *Poles* of the *Dial* are here all one with the *Axis* and *Poles* of the World, and the Hour-lines here meet all at the *Center*, making equal *Angles*, and dividing the *Dial* Circle into 24 equal parts, as the *Meridians* do the *Æquator*, in whoſe Plane the *Dial* lies.

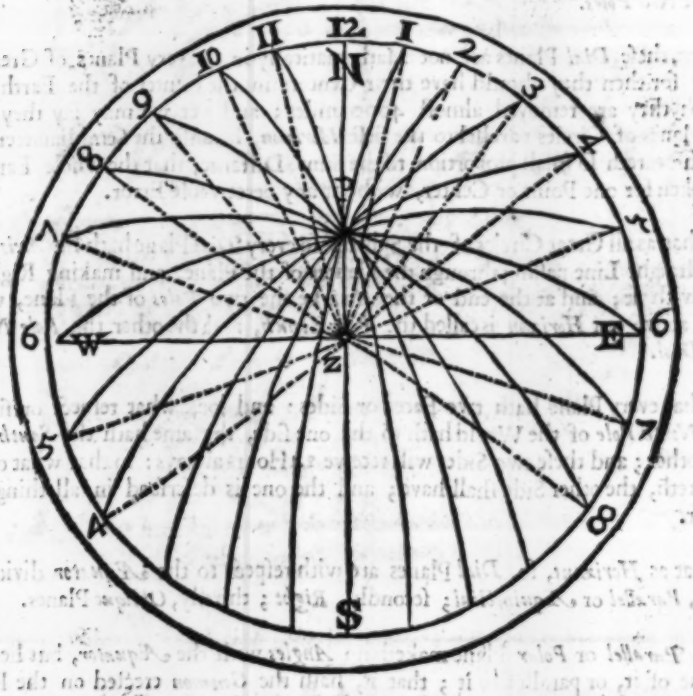
VII. A Right *Horizon* or *Dial* Plane cutteth the *Æquator* at Right Angles, and ſo cutteth through the *Poles* of the World, that it hath the *Gnomon* parallel to the Plane, and ſo the Hour-lines parallel one to another; becauſe their Planes, though infinitely extended, will never cut the *Axis* of the World: yet have thoſe *Dials* a Center, though not for the meeting of the Hour-lines, *viz.* through which the *Axis* of the *Dial* Circle paſſeth, cutting the Plane at Right Angles, and cutting alſo (neer enough for the projecting of a *Dial*) the Circle of the World.

VIII. An Oblique *Horizon* or *Dial* Plane cutteth the *Æquator* at Oblique Angles; that is, hath for their *Gnomon* the ſide of a Triangle, whoſe Angles vary according to the more or leſs Obliquity of the ſaid *Horizon*: and the *Gnomon* ſhall always make an Angle with the Plane, of ſo many Degrees as the *Axis* of the World maketh with the Plane, or as either of the *Poles* of the World is elevated above the Plane.

IX. Every

IX. Every Oblique *Horizon* is divided by the *Meridians* or Hour-circles of the Sphere into 24 unequal parts; which parts are always leſſer, as they are neerer to the *Meridian* of that *Horizon* or Plane; and greater, as they are farther off: and on both ſides of the Meridian of the Plane, the Hour-circles which are equally diſtant in time, are alſo equally diſtant in ſpace. Whence it is, that the diviſions of one Quadrant of your Dial Plane being known, the diviſions of the whole Circle are likewiſe known.

X. The Hour-lines in an Oblique Dial, are the Sections of the Planes of the Hour-circles of the Sphere, with the Dial Plane: and becauſe the Planes of Great Circles do always cut one another in Halves by Diameters, which are ſtraight Lines paſ-



ſing through the common Center; therefore Lines drawn from the Center of the Dial, to the Interſections of the Hour-circles with the Great Circles of the Plane, ſhall be thoſe very Sections, and the very Hour-lines of the Dial.

XI. Every Dial Plane being an Horizon to ſome place in the Earth (as was ſaid *Theorem* I.) hath his proper Meridian, which is the Meridian cutting through the Poles of the Plane, and making Right Angles with the Plane. If the Poles of the Dial Plane lie in the Meridian of the Place, then is the Meridian of the Plane all one with the Meridian of the Place, and the Gnomon or Style ſhall ſtand erected upon the Noon-line, or Line of 12 a Clock, as in all direct Dials. But if the Plane decline, then ſhall the Subſtyle Line, or Line which the Gnomon ſtandeth upon, which is the Meridian of the Plane, vary from the Line which is the Meridian of the Place; and this Variation ſhall be Eaſt, if the Declination be Weſt of the Plane: And contrarily, becauſe the Viſual Lines, by which the Sphere is projected on Dial Planes, do, like the Beams of a Burning-glaſs, interſect or croſs one another in a certain Point of the Gnomon (to be aſſigned at pleaſure, and called *Nodus*) and ſo do all place and depaint themſelves on the Dial Plane, beyond the *Nodus*, the contrary way.

XII. Dials

XII. Dials are moſt aptly denominated from that part of the Sphere where their *Poles* lie, though ſome Authors have choſen to denominate them from the Circles in which their Planes lie; as the Dial Plane which lieth in the Æquinoctial, or Parallel to it, is called by many an Æquinoctial Plane; but I concur with thoſe who would rather call it a Polar Plane, becauſe the Poles thereof are in the Poles of the World.

CHAP. III.

How to make the Polar Dial, and how to place it.

THe Plane of the Polar Dial lieth in the Æquinoctial, where the 12 chief Meridians or Hour-circles divide both the Æquinoctial and this Plane into 24 Hours or equal parts; the Gnomon ſtands upon the Center at Right Angles with the Plane.

Firſt draw the Horizontal Line A B, and croſs the ſame at Right Angles with the Line C D; now on the Center at G, with the Chord of 60 Degrees, or with the Tangent of three hours, you may deſcribe the Circle A C B D, and about it make the Square E F H I; then take out of the Hour-line one Hour, and lay it from each corner, as E F H I both ways: alſo do the like with two hours as you ſee done, and from the Center at G draw Lines to thoſe Hour-points: ſo ſhall you have the Hour-lines in the Æquinoctial Dial; C D being the Meridian or 12 a clock Line, and A B the Eaſt and Weſt Line, ſerving for 6 in the morning at B, and 6 in the afternoon at A, and ſo number the reſt of the Hours in order: You need draw no more hours than from 4 in the morning unto 8 at night, for this Latitude of *Briſtol*, being neer 51 *d.* 30 *min.*

For the Gnomon or Stile, you muſt have a ſtraight Pin or Wyre ſet upright in the Center, of ſuch length as you ſee convenient; but if you will have it of ſuch a length as may neither be too ſhort nor too long, then take this Rule.

How by Calculation to find the length of the Stile, and Semidiameters of the Parallels of Declination.

IF it were required to proportion the Stile to the Plane, ſuppoſe the Semidiameter of the greateſt Parallel upon the Plane were but 6 Inches, and the Parallels ſhould be the 5 *d.* of Declination, the Rule is general.

As the Tangent of 45 deg. —— 1000000
Is to the Tangent-parallel of Declination 5 deg. —— 894195
So is the Semidiameter of the Plane 6 inches O A —— 277813
To the length of the Stile 53 parts —— 172010

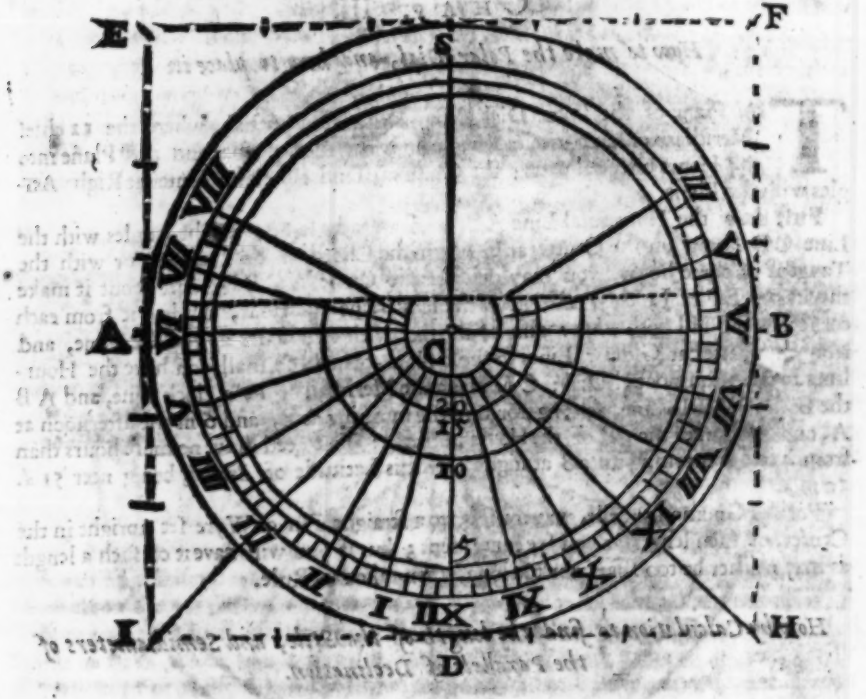
which ſhews that the length of the Stile muſt be $\frac{53}{100}$ parts of an Inch, divided into 100 parts.

How to find by the length of the Stile, the Semidiameter of the Parallel Circles of Declination.

SUppoſe the length of the Stile above the Plane to be 10 inches, and you were to find the Semidiameter of the Tropick, whoſe Declination is known to be 23 *deg.* 30 *min.* the Rule is for this and any other Declination.

As the Tangent of 45 deg. —— 1000000
Is to the length of the Stile 10 inches —— 100000
So is the Co-tangent of Declination 23 deg. 30 min. —— 1036169
To the Semidiameter of his Circle 23 inches —— 136169

which ſhews the Semidiameter of the Tropick to be 23 inches: So if the Declination be 20 *d.* the Semidiameter will be 27 inches $\frac{87}{100}$; if 15 *d.* then $37\frac{32}{100}$; if 10 *d.* then $56\frac{71}{100}$; if 5 *d.* then $114\frac{105}{100}$; and ſo of any other height of the Stile: as admit it were $\frac{159}{100}$ parts of an inch high, then the Semidiameter of 23 *deg.* 30 *min.* would be $1\frac{21}{100}$, and for 20 *deg.* it will be $1\frac{37}{100}$, and for 15 *deg.* $1\frac{69}{100}$; if 10, then $2\frac{98}{100}$; if 5 *deg.* then 6 inches; if Stile be $\frac{13}{100}$ and $\frac{75}{100}$, the Semidiameter 23 *deg.* 30 *min.* is $\frac{37}{100}$ parts, as you may ſee the Figure makes all plain; and ſo of any other.



Of all Dials this is the plaineſt; for it is no more but divide a whole Circle into 24 equal parts: and this is the very ground to all the reſt.

With this Dial, the Hour-lines being equally divided into 24 equal parts, on the inner circle you may make a Mariners Compaſs, with the 32 Points drawn upon it, to know in all Latitudes whether the Moon being upon ſuch a Point maketh High-water; or upon what Point the Moon muſt be, when at thoſe Places ſet together it maketh High-water or Full-Sea.

For to know upon what Point the Moon is, may be done two manner of ways; by ſetting it by the Compaſs, or by reckoning according to the age of the Moon, and the Hour of the day. The ſetting according to any Point, may not be done with a common flat Compaſs as the Mariners ſteer by (as many, wanting better reaſon, think they may, to their great miſtake) by reaſon it doth only divide the Horizon into equal Points, and ſheweth in what Vertical Circle or Azimuth the Sun or Moon ſtands: But this muſt be done with a Compaſs, which being elevated according to the Superficies of the Æquinoctial, divideth the Æquinoctial ſo likewiſe into equal parts; as the common flat Mariners Compaſs doth divide the Horizon. Such an Æquinoctial Compaſs, with a Dial in, as aboveſaid, is of faſhion as hereafter followeth pourtrayed. Whereof the Wheel A B C ſheweth the Superficies of the Æquinoctial, the Wyre E D the Axle-tree of the World. The foreſaid Wheel muſt be all alike marked on both ſides, as well under as above, with the 32 Points of the Compaſs, and with twice 12 Hours: and right againſt the Eaſt and Weſt at L and M, muſt ſo hang upon two Pins, as upon an Axletree, that it may be turned

up



up and down, and the Wyre at the under end at D, by the Quadrant F D G, may be ſet unto any height of the Pole. If then you ſet ſuch a Compaſs with the under bottom level, the Line H K North and South, *viz.* H to the North, and K to the South, and the under end of the Wyre right againſt ſuch a Degree of the Quadrant F G, as the height of the Pole that you find your ſelf in, then ſhall the Wheel A B C ſtand equal with the Superficies of the true Æquinoctial, and the Wyre E D with the Axle-tree of the World; and the ſetting by ſuch a one, and a common Compaſs, giveth great Difference. And the neerer the Æquinoctial, the greater; as may be underſtood by the Examples following.

EXAMPLE I.

IN the height of 50 *deg.* or thereabouts, the Sun being in the beginning of *Cancer*, at his greateſt Declination to the North, by a common Compaſs cometh not before half an hour after ſeven of the Clock to the Eaſt, and at half an hour after four to the Weſt; that is, he goeth from the Eaſt to the South and round to the Weſt in nine hours; but from the Weſt through the North, until again in the Eaſt, in 15 hours.

EXAMPLE II.

IN the height of 30 *deg.* he cometh a little before half an hour paſt nine of the clock to the Eaſt, and a little after half an hour paſt two of the Clock in the Weſt, and ſo goeth in leſs than five hours and a half from the Eaſt through the South to the Weſt; but from the Weſt through the North, until again in the Eaſt, he goeth more than 18 hours. Thirdly, Being under the Line, and the Sun having no Declination, he ariſeth in the morning right in the Eaſt, and ſo riſing higher and higher, continueth Eaſt until that he goeth over our heads through the Zenith into the Weſt; and ſo continueth Weſt, ſtill going down Weſt, until he cometh again to the Horizon: and ſo according to a flat Compaſs he is the one half of the day Eaſt, and the other Weſt, without coming upon any other Point. It is not ſo with this Æquinoctial Compaſs. The Sun and Moon go always a like time on every one Point of the Compaſs, to wit, from the Eaſt to the South 6 hours, from the South to the Weſt 6 hours, from the Weſt through the North to the Eaſt in twice 6 hours.

This Dial will ſerve for all Latitudes, if you put the end of the Wyre at D, to the height of the Pole or Latitude of the place as beforeſaid; ſo the ſhadow of the other end at E will fall upon the Hours and true Points of the Compaſs, all the time the Sun is to the North of the Æquinoctial: but when the Sun is to South of the Æquinoctial, you muſt look for the Hours and Points of the Compaſs upon the under ſide of the Dial.

Chap. IV.

How to make the South Æquinoctial Dial, or Polar Plane.

THe Æquinoctial Dial we call that which hath his Poles in the Æquinoctial Circle, of which there be three kinds.

1. The Direct or South Æquinoctial Dial, which faceth the Meridian directly, not looking from him to the one side more than to the other, having his Poles in the Intersections of the Æquinoctial and Meridian.

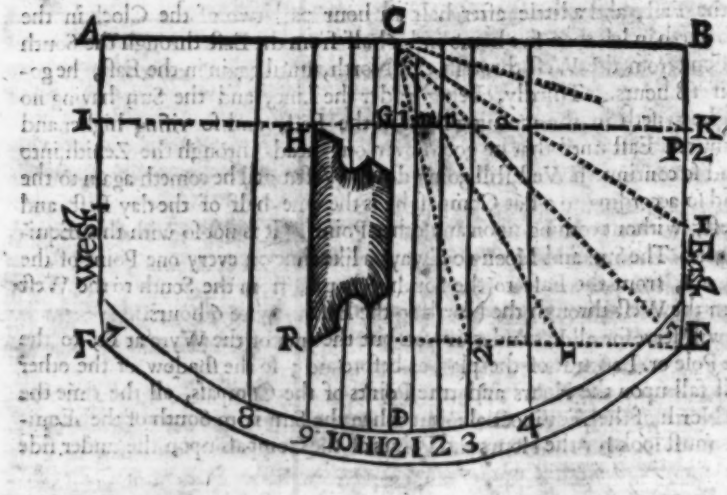
2. The East or West Æquinoctial Dials, which may also be called Æquinoctial Horizontal Dials; for an Horizontal Dial declining just 90 Degrees from the South or North, becomes an Æquinoctial Dial, as well as Horizontal, because there is his Polar height, upon the Intersection of the Horizon with the Æquinoctial: and though this Dial be of kin to both, yet his Gnomon shews that he should be sorted rather with the Æquinoctial Dials, than with the Horizontal. These two sorts are regular, having the Poles in the four notablest Points of the Æquator. The third is somewhat irregular, but may be brought to Rule.

How to make the first of these, draw the Horizontal Line A B, and about the midst at C let fall the Perpendicular C D, which is the Meridian or 12 a clock Line. Let C D be equal to a Chord of 60 Degrees, or the Tangent of three hours, and through D draw the Line F E, parallel to A B; make also D E and C B equal to D, so have you a true Square C D E B. Now take one hour with your Compasses off your Scale, and lay the same both ways from E towards B and D, as E 1. Do the like with two hours, and draw the pricked Tangent-lines from C to these Marks.

Next, Let the length or height of the Gnomon or Stile be G H, equal to C G, or 3 hours; so drawing a Line through G H, parallel to the Horizon, you shall find it cut the former Lines drawn to the Center C, in the Points l, m, n, o, p: through which Points, if you draw Parallel-lines to the 12 a clock Line C D, you shall have all the afternoon hours as far as V: and the morning hours must be drawn in like manner and distance, to the left hand or West side, beginning from 7 in the morning unto 12, as in the Figure following.

Note, that the height or length of the Stile is always 3 hours from the Meridian, as you see H G, which you may make with Copper or Brass Plate, or Iron, in form as you see shadowed, whose breadth on the top is here H R, which may be made more or less as you please.

This Dial will serve in any Latitude, if the Plane be placed parallel to the hour of 6, so that the Plane be even with the Pole of the World.



How

How to calculate the Height of the Stile, and the Points of Hour-distance from the Meridian.

SUppose the length of the Horizontal Line A B or F E be 12 Inches, and that it were required to put on all the Hours from 7 in the morning to 5 in the evening; here we have 5 hours and 6 inches on either side of the Meridian, wherefore I allow 15 Degrees for an hour. The Rule to find the height of the Stile is,

As the Tangent-compl. of the given Hour 15 deg. —— 1957194
Is to half the Horizon or Distance from the Meridian 6 *inches* — 277815
So is the Tangent of 45 *Degrees* —— 1000000
To the height of the Stile [illegible] —— 226621

And likewise the distance of the Hour-points of 8 and 3 from the Meridian will be $1\frac{61}{100}$, or 1 inch and 61 parts of 100.

How to find the length of the Tangent between the Substile and the Hour-Points.

HAving found the length of the Stile in our Example to be 1 inch 61 parts of 100, then in this Example, as we find the first Hour, so find the rest.

As the Tangent of 45 *deg.* —— 1000000
Is to the Tangent of the Hour from the Meridian 15 *deg.* —— 942805
So is the height of the Stile $1\frac{61}{100}$ *inches* —— 226621
To the length of the Tangent-line between the Meridian or Substiler $\frac{43}{100}$ *inch* —— 103416

Hours		An. Po. deg.	mi.	Tang. In.	par.
12		0	0	0	0
11	1	15	0	0	43
10	2	30	0	0	93
9	3	45	0	1	61
8	4	60	0	2	79
7	5	75	0	6	0
6	6	90	0	*Infinit.*	

and the Hour-point of 1 and of 11 a clock. And so of the rest, take them off a Scale of an Inch divided into 100 parts, and prick them from C and D both ways to B A and E F, and draw the Hour-lines parallel to the Meridian; and so do with the rest, until it be finished, as you may see by the Table.

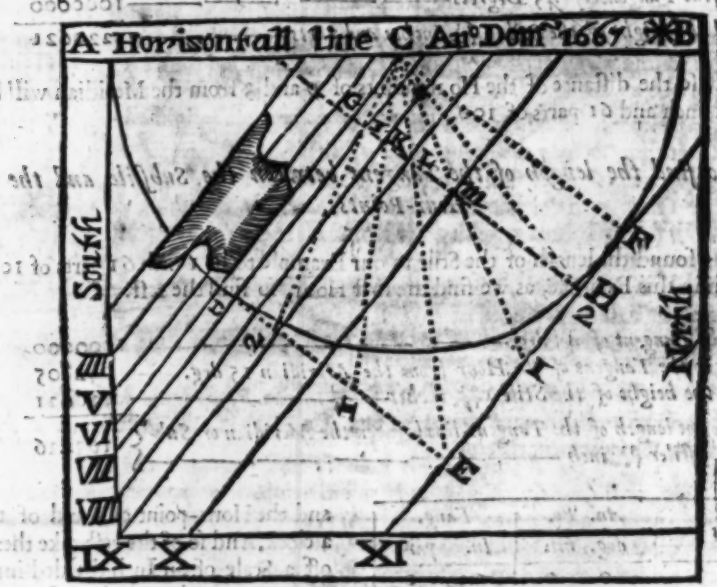
CHAP. V.

How to make the East Æquinoctial Dial, or the West Lat. 51 d. 30 m.

THis Plane is a right Horizon of those People who dwell under the Æquator, distant from us 90 deg. of Longitude; as the South Æquinoctial Plane of the last *Chapter* was the Horizon of those who dwell under the Æquator in the same Longitude with us: Therefore these Dials are in all Points alike, only the Substiler Line, which in the South Æquinoctial Dial is at 12, is but 6 in the morning for our Country, because of the difference of Longitude.

To pourtraict this on a Wall or Plane, first draw the Horizontal Line A B; then upon the Center C describe the Semicircle A D B, whereon lay the Latitude of the place 51 d. 30 m. from A unto D; so drawing G D continued, you shall have the Hour of 6: then with your Compasses take off your Scale 15 deg. of the Line of Chords, and turning them off 6 times, divide the Arch D F into 6 equal parts, and draw

draw prick'd or blind Lines to thoſe Diviſions, which would be all one as if you had done it thus. CD being equal to the Chord of 60, or Tangent of 3 hours, you ſhall make the Quadrant or true Square equal to the ſide thereof C D E F, and from the corner at E, you ſhall lay down both ways towards D and F the hours of 1 and 2, from whence draw Lines to the Center C: Next make choice of the length or height of your Pin or Stile, which you muſt lay down from C to G on the 6 hour Line, drawing from the Point G a Line perpendicular to the Line of 6, or parallel to the ſide C F, as G H, which cuts the former Lines in the Points I K L M H; through which Points drawing Lines parallel to the hour of 6, you ſhall have the morning hours from 6 to 11, and the hours before 6, from 4 in the morning, are equal as from 6 to 7 and 8.



How to make the weſt Æquinoctial Dial.

THe Weſt Æquinoctial Dial erect, ſerving for the afternoon, is drawn by the ſame Rules contrariwiſe like the Eaſt in all points, only it ſhews but the afternoon hours, as the Eaſt ſhews the forenoon hours: When you have drawn on paper the Eaſt Dial, and ſet it by gueſs in its ſcituation, go on the Weſt ſide of it, and you may ſee through the paper the picture by reflection of the Weſt Dial; and ſo will the picture of the backſide of the Weſt ſhew you the true picture of the Eaſt Dial.

The way to calculate the height of the Stile, and the diſtance of the Hour-lines from the hour of 6, is the ſame as in the laſt Chapter of the Polar Plane: For ſuppoſe the length of the Stile to be 10 inches, then the length of the Tangent-line belonging to the firſt hour will be 2 inches and 68 parts of 100, as you ſee in this Table for the reſt of the hours, which taken off a Scale of equal parts, and prick'd from the Æquinoctial from C towards F, and likewiſe upon the parallel D E: ſo you will make a Dial all one as by the former way, which is good proof, if you draw the Hour-lines through theſe two Points; and ſo of the reſt.

Hours.		*Ang. Po.*		*Tang.*	
		deg.	*min.*	*In.*	*par.*
5	7	15	0	2	68
4	8	30	0	5	77
3	9	45	0	10	0
10	2	60	0	17	32
11	1	75	0	37	32
12		90	0	*Infinit.*	

CHAP.

CHAP. VI.

Of the kinds of Oblique Dials.

WHat an Oblique Dial is, and why it hath been ſo called, hath been ſhewed *Chap.* 2.

They be { Regular. / Irregular.

The Regular lie in ſome notable Circle of the Sphere; as firſt the Vertical Dial, whoſe Plane lieth in the Horizon, for which cauſe many call it the Horizontal Dial. Secondly, the South and North Horizontal Dials, whoſe Plane lieth in the Eaſt Azimuth, and is commonly called the South or North erect direct Dial. As for the Eaſt and Weſt Dials, they belong to another place, as was ſaid Chap. 5.

The Irregular are ſuch as lie Oblique to the Horizon, as Reclining or Inclining Dials; or elſe lie Oblique to the Meridians, as Decliners; or elſe Oblique to both, as Recliners or Incliners declining, which are eſteemed the hardeſt of all, becauſe of their double irregularity.

The Declination of a Plane is the Azimuthal Diſtance of his Poles from the Meridian of the place Eaſt or Weſt.

The Reclination is the diſtance of his Poles from the Zenith and Nadir of your place.

Inclination is the neereſt diſtance of the Poles of the Plane from your Horizon; and whatſoever the reclination of the upper face of a Plane is, the inclination of the lower face is the Complement thereof.

CHAP. VII.

How to make the Vertical Horizontal Dial.

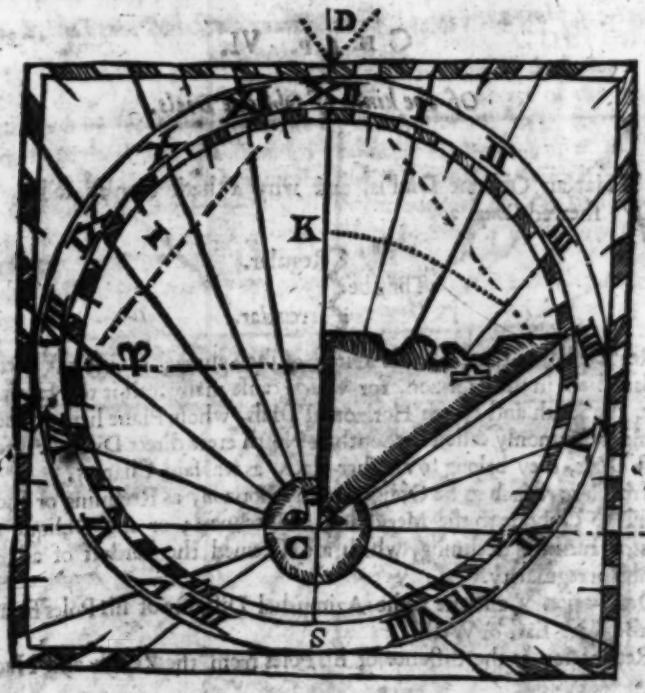
DRaw firſt the Horizontal-line A B, which is the Hour-line of 6; then take the Latitude of 51 *d.* 30 *m.* from the Gnomon-line, and lay it down both ways from the Center C, as to A and B. Next take the whole Hour-line of 6, fixing one leg of your Compaſſes on A, deſcribe a little Arch towards D; do the like from the Point B, croſſing the Arch at D; ſo draw the Line A D and B D. Now upon theſe Lines you muſt tranſport the 6 hours from D unto A, and alſo from D unto B, as you ſee by the Figures 1, 2, 3, 4, 5, from whence drawing Lines from the Center C, you ſhall have the Hours as you ſee numbred from 4 in the morning until 8 in the afternoon, which ſufficeth for this Latitude 51 *d.* 30 *m.*

Take off the Scale of Hours the half's and quarters, and prick from D as you did the Hours, and draw the quarters in the Dial as you were directed for the Hours.

For the height of the Stile, take off your Line of Chords with your Compaſſes the Latitude of the Place 51 *d.* 30 *m.* and lay from K to E, from 12 to neer 4, and ſo drawing C E, you have the height of the Stile, which may be made in Brals or Copper Plate, as you ſee ſhadowed in the Dial following.

This by Calculation,

As the Sine of 90 *d. Is to the Sine of the Latitude* 51 *d.* 30 *m.* —— 989354
So is the Tangent of the Ho. 15 *d.* —— 941804
To the Tangent of the Hour-line from the Meridian 21 *d.* 50 *m.* — 931159



As in this Table, which take from the Line of Chords, and prick from the Meridian 12 from K on each ſide, the Degree or Tangent of each hour; And by the ſame Rule you may find the Quarters, and that you may prick off in like manner, which is a way how to make an Horizontal Dial, as before, Latitude 51 *deg.* 30 *min.*

Hours.	*Gr.*	*mi.*	*Gr. Tangents.*	*mi.*
12	00	00	00	00
1	15	00	11	50
2	30	00	24	20
3	45	00	28	3
4	60	00	53	35
5	75	00	71	06
6	90	00	90	00

CHAP. VIII.

A South and North Erect Direct or Horizontal Dial, and how to make it.

THis belongs to an upright Wall looking full North or South, and the Plane of it lies in the East Azimuth.

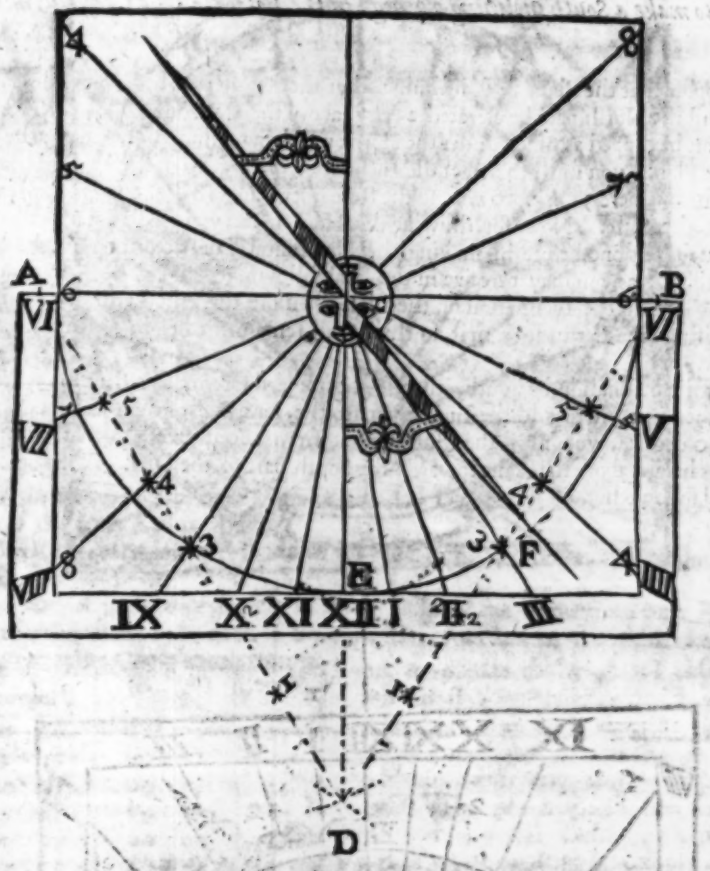
First draw the Horizontal-line A B, which ſerveth for 6 in the morning at A, and 6 in the afternoon at B; then from the Center lay down from C the Gnomon of the Latitudes Complement 33. 30 both ways, as to A and B: Now with the whole Line of 6 hours from A deſcribe an Arch towards D, and with the ſame diſtance from B croſs the ſame Arch, and draw the two Lines A D and B D, whereon from D you muſt tranſport the hours, as you ſee by the Figures 1, 2, 3, 4, 5. So drawing Lines through thoſe parts from the Center C, you ſhall have the hours from 6 a clock in the morning to ſix a clock in the afternoon.

With the Chord of 60 on the Center C deſcribe the Semicircle A D B from which Line of Chords take the Complement of the Latitude 38. 30, and lay down from the Meridian at E unto F; ſo drawing C F, you ſhall have the height of the Stile

	90	
Lat.	51	30
Compl.	38	30

above

above the Plane. This, if it be for a large Dial, as againſt a Wall, is beſt to be made of a Rod of Iron; for ſmall Dials a Braſs Plate is beſt, and your Dial is done.



This Dial ſhews the Hours from 6 in the morning to 6 at night: The other hours before and after 6, as far as four and eight, belong to the North face of this Dial. Becauſe the Almicantars may oft obſcure the Interſections of the Hour-circles, you may avoid that if you reduce this Dial to a Vertical Dial, for the South Horizontal Dial, being the Vertical Dial of thoſe People who live 90 degrees Southward from us, that is, in 38 *d.* 30 *m.* of South Latitude.

Secondly, For the North face, imagine you had for the Gnomon a Wire thruſt aſlope through the center of the Plane from the Southſide Northward, and you will preſently conceive, that in the North Dial the Horizontal or 6 a clock Line will be loweſt, and that the Stile or Gnomon will turn upwards towards the North Pole, as much as it turned downwards on the other ſide; and that all the Hours ſave 6 in the morning, and 6, 7, 8 at night, may be left out in our Latitude, becauſe the Sun ſhineth no longer upon it; and thoſe Hour-diſtances you may find and ſet off from 6 a clock Line, as you did the Hours of like diſtance in the South face. Note in a South erect direct, or a South erect declining Dial, the Scile always points downwards; but if it be a North erect declining Dial, the Scile points upwards.

CHAP. IX.

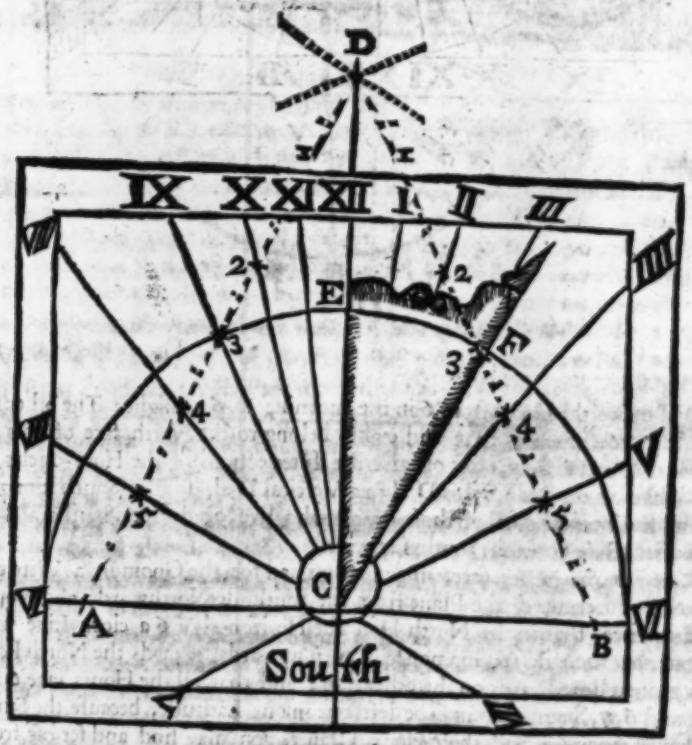
How to make a South inclining 23 deg. in the Latitude of 51 deg. 30 min.

SUppoſe that the Plane be ſo inclining, that the face thereof be towards the South, and the North part be elevated 23 *deg.* above the Horizon, and that the South part be dipped as much under the Horizon; then to find the height of the Stile above the Plane, you muſt ſubſtract the Inclination 23 *deg.* from the Latitude of the Place, which is here 51 *deg.* 30 *min.* ſo the Remainer being 28 *deg.* 30 *min.* ſhall be the height of the Stile. Now for drawing the Hour-lines, you ſhall do no otherwiſe than you have done before in making the Horizontal Dial according to the Stiles height 28. 30, as you may perceive in the Dial following.

	d.	*m.*
Lat.	51	30
Incl.	23	
H. Stile.	28	30

Note, That if the Inclination of the Plane be more than the Latitude, then you muſt ſubſtract the Latitude from it, ſo there ſhall remain the height of the Stile above the Plane.

But if the inclination be South, that ſo the upward face of the Plane looks Northward, then you are to add the Inclination to the Latitude of the Place; and if it exceed 90 degrees, you muſt then ſubſtract it from 180 degrees, ſo ſhall you have the Poles height above the Plane towards the South part of the Dial. The Figure of this Dial followeth.

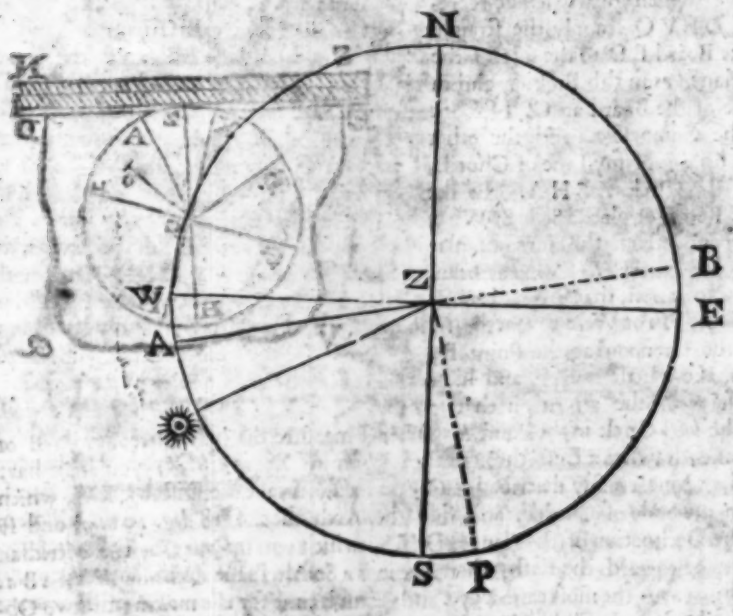


CHAP.

CHAP. X.

How to observe the Declination of any Declining Plane.

ALL perpendicular Planes, as Walls, lie in the Planes of one of the Azimuths; which Planes cut always both Zenith and Nadir, and the Center of the Earth, as in the Figure Z is Zenith and Nadir E S W N. Horizon E W is the Base or Ground-line, or any Horizontal Line, drawn upon a Wall or Plane, looking full South or North: his Poles are at S and N in the Meridian; wherefore he declineth not, but lieth in the East Azimuth E W.



A B is a Wall or Plane declining East by the Arch S P, to which A B or W E are equal: for so much as the Wall bendeth from the East Azimuth, so much doth his Pole at P decline or bend from the Meridian.

Now to find how much any Plane declineth, and so in what Azimuth he lies, one good way is this. When the Sun begins to enlighten the Wall, or when he leaves it, then is the Sun in the same Azimuth with the Wall: therefore take at that instant his Altitude, and thereby get his Azimuth, according to *Chap.* 14. of the Sixth Book, so you shall have the Declination of the Wall.

Another way, if you have not time until the Sun cometh unto the Azimuth of the Wall, or the Vertical of it, which cutteth the Pole thereof, then get the Suns Azimuth as before when you can, and at the same time observe by the sight of your Circumferenter the Suns Horizontal Distance from the Pole of the Plane; and by comparing of those together, you may easily gather the Declination of the Wall: As in Example.

I observed the Sun to be gone West from the Pole of the Plane 72 *deg.* and by the Altitude of the Sun then taken, I found his Azimuth 62 *deg.* Here I reason thus: The Sun is gone from the Pole Vertical of the Wall 72 *deg.* and from the Meridian 62 *deg.* therefore the Meridian lies between the Pole of the Plane, and the Sun: And because ⊙ P is 72, and ⊙ S 62, therefore S P the Declination of the Plane is 10 *deg.* the Difference of 72 and 62; and the Declination is East. for the Sun is neerer to the Meridian, than to the Vertical of the Plane.

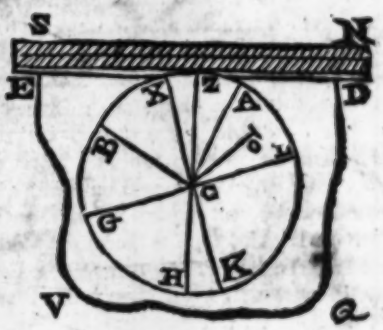
And thus if you draw a rude Scheme of your Caſe, you may ſoon reaſon out the Declination, better than do it blindfold, by the Rules commonly given.

And by thoſe two laſt ways you may take the Declination not only of upright Planes, but of Recliners alſo.

How to take the Declination of any Wall or Plane, without the help of a Needle or Loadſtone.

FOr Example. Suppoſe S N D E repreſent a Wall, or the face of the Plane whereon I am to make a Dial, and I deſire to know the Declination thereof from the Meridian Eaſtward or Weſtward.

If you have no Inſtrument, take a plain Board, having one planed or ſtraight ſide or edge, which Board let be repreſented by D E V Q: apply the ſtraight edge of the Board E D to the ſide of the Wall or Plane, as in this Figure, and in the middle of the Board at C, I ſet one foot of the Compaſſes, and the other opened to 60 *deg.* of my Line of Chords, I deſcribe the Circle Z B H A. In the Center C, I ereſt or place a Stile or Wire, as C O perpendicular to the Horizon, placing the Board as neer *Horizontal* as I can. I find by obſervation, that the ſhadow of the top of the Pin or Wire toucheth the Circle in the forenoon at the Point B, where I make a little mark; and likewiſe I obſerve in the afternoon that it toucheth the ſaid Circle in the Point A: Then I meaſure the half thereof from B or A to X, and drawing a Line through the Center to X, as K C X, you ſhall have the Meridian Line exactly deſcribed K C X. Laſtly, I take the Diſtance Z X, which I apply to my Scale of Chords, and find the Arch thereof 18 *deg.* 10 *min.* and ſo much is the Declination of th Plane E D N S, which you may ſee by the Meridian Line X K to be towards the Eaſt; therefore it is a South Plane declining Weſt 18 *d.* 10 *m.* This way is the moſt eaſie way, and requires time for the making the two Obſervations; therefore I will lay down ſome other ways, that may reſolve at one moment, or at one obſervation.



How to find the Declination by the Needle, whether the Air be clear or not.

APply the North ſide of the Inſtrument wherein the Needle is placed unto the Wall, and hold it Horizontally as neer as you can, that the Needle may have liberty to play to and fro; and when it ſtands, obſerve upon the Limb of the Chard over which it moves, upon what Degree the Needle ſtands; for that is the Declination of the Plane, reckoned from the South Point of the Needle: And if you would know the Coaſt, obſerve, That if the Needle ſtand upon the Eaſt ſide of the Meridian Line, then is the Declination Weſt; but if it ſtand on the Weſt ſide of the Meridian Line, the Declination is Eaſt. By the Sea-Compaſs deſcribed Book V. as it hangs in the Box, you may alſo find the Declination. Set the ſlit of the Braſs Diameter North and South, as before directed; then ſet the ſquare ſide of the Compaſs-box next the Plane, reckon outwards 180 *deg.* and ſet the Index to it; ſo reckon the number of Degrees betwixt 180 the Index, and the Meridian, and that number of Degrees is the Declination of the Plane required; and by the Chard you may ſee what Coaſt it is, that *is*, whether he declines from the North or South Eaſtward or Weſtward. And note, That all Lines parallel to any Horizontal Line be Horizontal, and all Lines parallel to Vertical Lines be alſo Vertical.

CHAP.

CHAP. XI.

How to make a Declining Horizontal Dial, or South erect declining from the South Eastwards 32 deg. 30 min. *in the Latitude of* 51 deg. 30 min.

HEre three things are required; for besides the Distance of the several hours from 12, and the Elevation of the Gnomon, which are requisite to the making of all direct and regular Dials, we must here also know the Declination of the Gnomon, which some call the Distance of the Substile from the Meridian, or the distance of the Meridian of the Plane from the Meridian of the Place. For in all Dials the Noon-line is the Meridian of the Place, projected on the Dial, and in all Horizontal or Mural Dials, not reclining or inclining, the Noon-line is a Perpendicular cutting the Center of the Dial, how much soever they decline.

But declining Dials which look awry from our Meridian, have a Meridian of their own, which is called the Meridian of the Plane and the Substile (because the Stile or Gnomon stands upon it) and is indeed the Meridian of that Place where this Declining Dial would be a Vertical Dial, and where the Substile would be Noon-line; and to this Substile the Hours of the Plane are always so conformed, that the neerer they be to the Substile, the narrower are the Hour-spaces; and contrarily, because the Meridians do cut every Oblique Horizon, that is thickest neer the Meridian of the place; and this Declining Dial being a Stranger with us, followeth the fashion of his own Country, and so hath his narrowest Hour-spaces neer his own Meridian, rather than ours: And now, as that is the Meridian of our place, which cutteth our Horizon at Right Angles, passing through his Poles, Zenith, and Nadir; so the Meridian of any Plane is that which cutteth the Plane at Right Angles, and passeth through his Poles.

Before we draw the Hour-lines in these sort of Dials, it will be very convenient to shew a general way for all Latitudes in a Diagram by it self, and how to find the Substiler Distance from the Meridian or 12 a clock Line, and the height of the Gnomon or Stile above the Plane. First, Draw the Horizontal-line A B, and upon the Center at C, take off your Scale with your Compasses a Chord of 60 Degrees, describe the Semicircle A D B, and with a Chord of 90 you may lay from A to D, and from B to D, so shall you draw C D from the Meridian-line of 12 a Clock; Then take the Complement of the Latitude 38 *deg.* 30 *min.* and lay from D to E, and so draw E F parallel to the Horizon A C; next take the Declination of the Dial 32 *d.* 30 *m.* and lay from D to G, drawing the *Radius* O G thereon, you must lay the Distance E F from the Center at C, as C H. Now with the neerest distance from H to the Meridian C D, as H I, make F L; and drawing a Line from C through L, it will cut the Limb in the Point M; so measuring D M on the Line of Chords, you shall have the Substiler Distance 23 *deg.* 8 *min.* all which you may see in this Scheme following.

By Calculation,

As the Radius 90 *deg.*	10
Is to the Sine of the Declination S E 32 *deg.* 30 *m.*	973021
So is the Co-tangent of the Latitude 51 *d.* 30 *m.*	990060
To the Tang. of the Substiler Diff. from the Meridian 23 *d.* 8 *m.*	963081

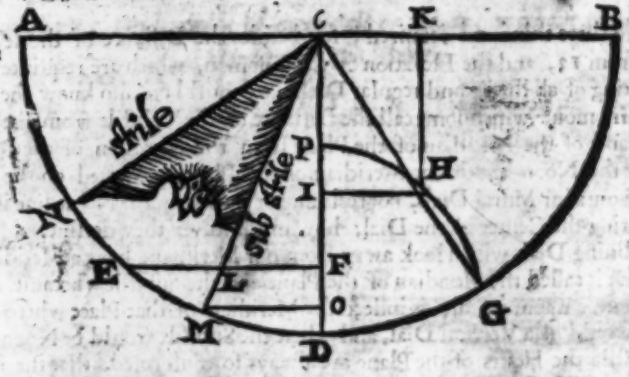
For the height of the Stile, take the neerest Distance from H to the Horizon K, and lay the same from L to cut the Arch in N: So measure M N, you shall have on the Line of Chords the Height of the Stile neerest 31 *deg.* 40 *min.*

By Calculation, *viz.*

As the Radius 90 *deg.*	10
Is to the Co-sine of the Latitude 51 *deg.* 30 *min.*	979414
So is the Co-sine of the Declination 32 *deg.* 30 *min.*	992602
To the Height of the Stile 31 *deg.* 40 *min.*	972016

To

To find what Hour or how much Time the Subſtiler is diſtant from the Meridian or Inclination of Meridian.



TAke the neereſt Diſtance from M to F E, and lay it on the Meridian from F to O: Then take the Diſtance from O unto G, and lay it from O unto P on the Meridian; ſo the Diſtance from P to M, meaſured on a Line of Chords, will be found to be 39 *deg.* 9 *min.* or thereabouts; which in time, allowing 15 *deg.* for an hour, and four Minutes to a Degree, you ſhall have 2 *ho.* 36 *min.* 36 *ſec.* which is the diſtance of the Subſtile Line from the 12 a Clock Line, which in this Dial is between 9 and 10 of the Clock in the morning. And by Calculation,

As the Radius 90 *deg.*	10
Is to the Sine of the Latitude 51 *deg.* 30 *min.*	989354
So is the Co-tangent of the Declination 32 *deg.* 30 *min.*	1019581
To the Co-tangent of the Inclination 39 *deg.* 9 *min.*	1008935

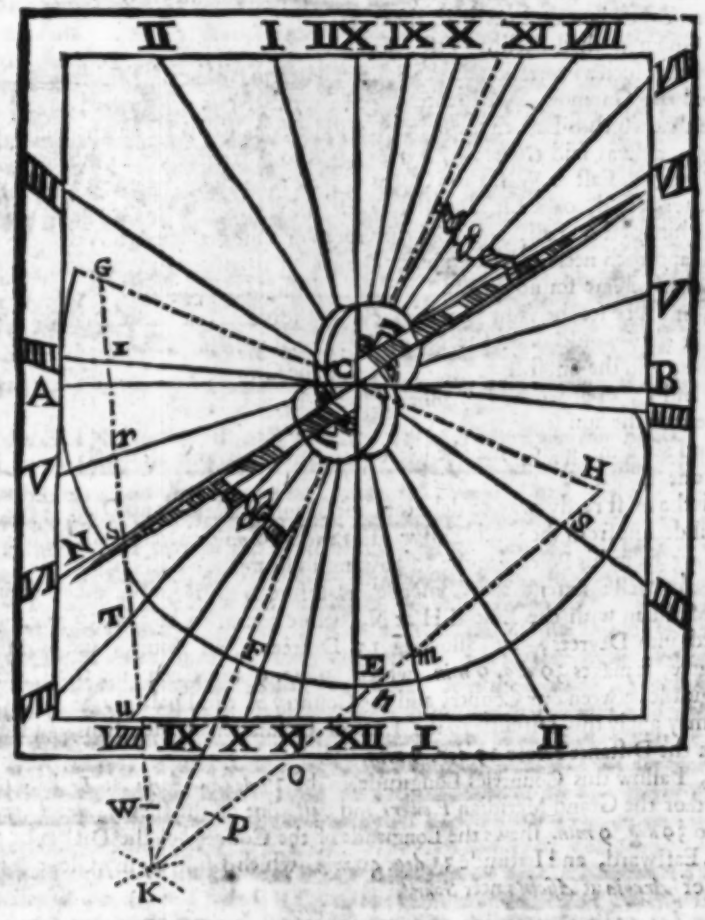
Thus is ſhadowed a Geometrical way, and by Calculation, for any Latitude: But for one particular Latitude, Mr. *Philip Staynred*, which firſt compoſed the Scale and Guomon Line, and Inclination of Meridians, and the greater and leſſer Pole on the Dialling Scale, for 37 years ſince, as I have ſeen by him calculated, and the Projection Geometrical in his Study: he hath for the more eaſe ſet two Lines upon the Dialling Scale, as he uſually makes, to find the Subſtile for the Latitude of 51 *deg.* 30 *m.* againſt the Lines ſtands the Letters *Sub* or *Stile* joyned with it; ſo if you take from off the Subſtile-line the Declination of the Dial, and lay it from D unto M, which in the laſt Example was 32 *deg.* 30 *min.* you ſhall find it to reach in the Diagram from D unto M, as in the Line of Chords 23 *deg* for the Subſtile, as before. Alſo, the other Line noted with the word *Stile*, you ſhall likewiſe take from thence the Declination 32 *deg.* 30 *min.* which you ſhall find to reach in the Diagram from M unto N, or in the Line of Chords 31 *deg.* 40 *min.*

CHAP. XII.

How to draw the Hour-Lines in a Declining Horizontal-Dial, or South erect, declining 32 deg. 30 min. *from the South Eaſtward, the Latitude being* 51 deg. 30 min.

FIrſt draw the Horizontal Line A B, and on the Center at C deſcribe the Semicircle A E B, with the Chord of 60 *deg.* and from A and B lay down 90 *deg.* unto E; ſo ſhall you draw C E the Meridian Line or Hour of 12; then in the

the former Diagram take the Subſtile diſtance D M 23 *deg.* and lay the ſame in the Dial following from E unto F, and from the Center C through F you ſhall draw C F K the Subſtiler Line. Next take the Chord of 90 *deg.* and lay it from F both ways upon the Arch, ſo ſhall you draw the Gnomon Line G H, whereon from C, with the Stiles Altitude before found, 31 *deg.* 40 *min.* taken from the Gnomon Line, you ſhall make C G and C H. Then take the whole Line of 6 hours, and with the ſame diſtance from G deſcribe an Arch at K, and with the like from H croſs the ſame Arch, and draw the Lines G K and H K, which laſt Line cuts the Meridian at N. Now if you meaſure K N on the Hour-lines, you ſhall find it neer 2 *ho.* 36 *m.* as you found in the laſt Diagram. Then take one Hour more, which is 3 *ho.* 36 *min.* and lay the ſame from K unto M; and ſo increaſing one Hour more, you ſhall have the Hour points *l* and *i*; alſo diminiſhing one Hour leſs than 2 *ho.* 36 *min.* which is 1 *ho.* 36 *min.* the ſame will reach from K to O, and ſo 38 *min.* from K to P. Now as you have divided K H, the very ſame diſtance as is from K towards H, muſt be from G towards K; ſo drawing the Lines from the Center C through thoſe Points, you ſhall have the Hour-lines, as you ſee in the Dial following.



By Calculation,

As the Radius 90 *deg.* —— 10
Is to the Sine of the Stiles or Gnomons Height 31 *d.* 40 *m.* —— 972013
So is the Tangent of the Diſt. of an Hour from the Su: ſt. 9 *d.* 9 *m.* - 910701
To the Tangent of the Hour-Arch from the Subſtile 4 *d.* 50 *m.* } 892714
betwixt the 10 *a clock Line, and the Subſt. Line on the Arch* }

By

By this Rule was this Table made; and by the ſame you may make one for any Latitude, and for any Declining Dial; and you may by it prove your former Work: for if you prick from the Subſtiler Line F the Chord of 4 *deg.* 50 *m.* and draw a Line from the Center, it will be the Hour-line of 10; and prick the Chord of 3 *deg.* 5 *min.* from the Subſtile, and draw a Line through that Point to the Center, and it will be the Hour-line of 9 a clock; and ſo of the reſt, as you find them in the laſt Column.

Hours.	*Equal. Diſt.*		*Hour Arches.*	
	D.	*M.*	*D.*	*M.*
4	80	51	72	57
5	65	51	49	30
6	50	51	32	49
7	35	51	20	46
8	20	51	11	18
9	5	51	3	5
	Meridian.		*Subſtile.*	
10	9	9	04	50
11	24	9	13	15
12	39	9	23	8
1	54	9	36	0
2	69	9	54	2
3	84	9	78	57

Note, That the Height of the Stile FS being equal unto MN in the former Diagram, which is the Chord of 31 *d.* 40 *m.* now becauſe the Plane declines Eaſt, therefore the Gnomon ſhall decline Weſt: for the Dial being ſuch a Projection of the Sphere, wherein all the uſual Lines croſs in the Nodus of the Gnomon, and thence diſperſe themſelves again towards the Plane; therefore that which is Eaſt in the Sphere, will be expreſſed Weſt on the Plane, and contrarily, as was ſaid *Chap.* 2, *Theorem* 2. Alſo I conſider, that howſoever the Plane be turned Eaſt or Weſt, the Gnomon place is fixed, becauſe it is a part of the Axis of the World, or a Line Parallel to it. Now therefore I turn a South Dial, and make him decline Eaſt, and hold the Gnomon unmovable, the Weſt ſide of the Dial will approach neerer to the Gnomon, as reaſon and ſenſe will require. Likewiſe the Hours which are found on the ſame ſide of the Meridian or Noon-line with the Subſtile, muſt be ſet the ſame way with it from the Noon-line in the Dial.

And if you would draw the North Dial of this Plane, do but prolong thoſe Hour lines, and the Subſtile upwards beyond the Center, and you have the North Dial beyond C, or above the Horizontal Line A B, as the South Dial below it. And note, Becauſe the Sun ſets after 8 a Clock in Summer, therefore the three hours next before and after midnight, may be left out in this Dial, and all others which muſt ſerve in our Latitude.

This is the moſt ready way to delineate the oppoſite face of any Dial. Note, That if a Wall decline from the South Eaſtwards 32 *deg.* 30 *min.* therefore the Plane which lieth 90 *deg.* from his Pole, is in the 32 ½ Azimuth from the Eaſt Northward.

Note this well: Extend the Compaſſes as before from K to N, the Interſection of the Meridian with the Line K H at N, before found to be 2 *hr.* 36 *min.* which converted into Degrees, by allowing 15 Degrees to an Hour, and 4 Minutes to a Degree, it makes 39 *deg.* 9 *min.* which 39 *deg.* 9 *min.* ſhew me the Difference of Longitude between our Country and the Country of this Dial.

You may apply this Diſtance to the Line of Inclination of Meridians, and it will give you the Diſtance before 39 *deg.* 9 *min.*

Note, I allow this Countries Longitude to be 27 *deg.* 44 *min.* at *Briſtol*, to the Eaſtward of the Grand Meridian *Flowers* and *Calfs* one of the Iſles of *Azores*, which added to 39 *deg.* 9 *min.* ſhews the Longitude of the Country of the Dial to be 66 *d.* 53 *min.* Eaſtward, and Latitude 31 *deg.* 40 *min.* which I find by my Globe is in the Deſarts of *Arabia* at *Aſichia* neer *Soar*.

CHAP.

CHAP. XIII.

How to observe the Reclination or Inclination of any Plane.

WHat Reclination and Inclination are, hath been ſhewed *Chap.* 8. and you will have it following in a Diagram by it ſelf.

All Reclining and Inclining Planes have their Baſes or Horizontal Diameters lying in the Horizontal Diameter of ſome Azimuth; but the top of the Plane leaneth back from the Zenith of your place in the Vertical of the Plane (which is the Azimuth cutting the Plane at Right Angles) ſo much as the Reclination hapneth to be: and the Pole of the Plane, on that ſide the Plane inclines to, is ſunk as much below the Horizon, as the top of the Plane is ſunk below the Zenith; and the oppoſite Pole is mounted as much.

Let E S W N be Horizon, Z the Zenith, E W the Horizontal Diameter of the Plane and of the Eaſt Azimuth, E O W a Plane not declining but reclining Southwards from the Zenith by the Arch Z O 45 *deg.* and his oppoſite Face inclining to the Horizon according to the Arch O S 45 *deg.* the Pole of the reclining Face is at P in the Meridian C P, which here is alſo Vertical of the Plane, and is elevated 45 *deg.* in the Arch N P, equal to the Arch of Reclination Z O, the Pole of the inclining Face is depreſſed as much on the other ſide under the Horizon.

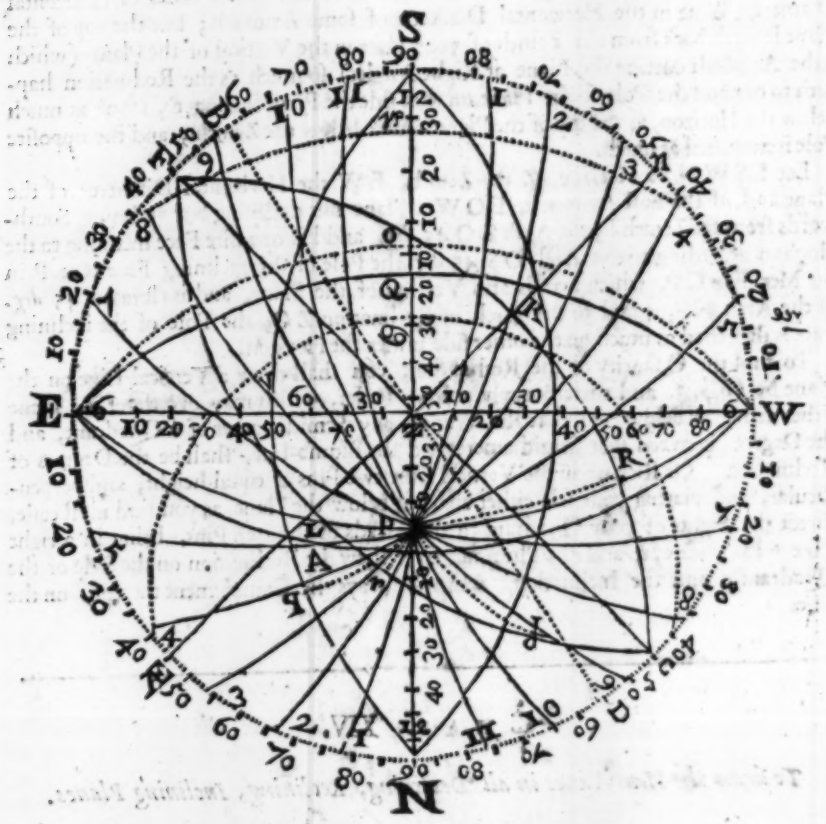
To find the Quantity of the Reclination, you ſhall draw a Vertical Line on the Plane by *Chap.* 3. and thereto apply a long Ruler, which may overſhoot the Plane either above or below: to that Ruler apply any Semidiameter of a Quadrant, and the Degrees, between that Semidiameter and the Plumb-line, ſhall be the Degrees of Reclination. Or ſtick up in the Vertical Line two Pins of equal height, and perpendicular, and placing your ſelf either above or below the Plane, as you find moſt eaſie, direct the Sights of your Quadrant to the Heads of the two Pins, being in a right Line with your eye; and the Plummet ſhall ſhew the Reclination on the Side of the Quadrant, and the Inclination, which is always the Complement thereof, on the other.

CHAP. XIV.

To draw the Hour-Lines in all Declining, Reclining, Inclining Planes.

IF a Plane ſhall decline from the Prime Vertical, and incline to the *Horizon*, and yet not lie even with the Poles of the World, it is then called a Declining, Inclining Plane. Of theſe there be ſeveral ſorts, you may ſee 19 Planes in the following Diagram, and directed how to know them in the 25th *Chapter*: but to ſhew the Recliners in order as they come, *viz.* the North Recliner 45 *deg.* and South Incliner falls between the Æquator and the Tropick of ♋, as the Circle E Q W; the South Recliner 45 *deg.* and North Incliner, falls between the Horizon and the Pole, and is repreſented by the Circle E A W. The Eaſt and Weſt Recliner and Incliner 45 *deg.* may be ſeen by the Circle N V S, the Inclination may be Northward 45 *deg.* and declining 45, as the Circle F K C, or the Plane may decline S 45 Weſtward, and recline 45 *deg.* from the Zenith, as the Circle C L F. If your Inclination or Reclination fall more or leſs, you may ſee the way. Each of theſe Planes have two Faces, the upper toward the Zenith, the lower towards the Nadir, wherein having the Latitude of the Place, and the Declination, with the Inclination of the Plane, you are farther to conſider what muſt be found before you can draw the Dial, which will follow in order, and is repreſented in this Fundamental Diagram; only I will mention the Arches and Angles in the hardeſt, which is a South declining Weſt 45 *deg.* and reclining from the Zenith 45 *deg.* In ſuch you muſt conſider.

1. The Arch of the Plane between the Horizon and Meridian C O or F O.
2. The Arch of the Meridian between the Horizon and the Plane O N or O S.
3. The Angle of Inclination between the Meridian and the Plane C O N or F O S.
4. The Subſtile-diſtance from the Meridian O R or O R.
5. The Height of the Pole above the Plane or Stiles Height P R.
6. The Inclination of both Meridians or Angles at P.
7. The Difference of the Hour from the Subſtile. But firſt we will deſcribe the Diagram.



To Deſcribe the DIAGRAM.

THe Deſcription of this Diagram is ſet down at large by that worthy Mathematician Mr. *Edmond Gunter*, in the *Uſe of his Sector*, *Chap.* 3. But for this purpoſe it may ſuffice, if it have the Vertical Circle, the Hour Circles, the Æquator, and the Tropicks firſt drawn in it; other Circles may be ſupplied afterward, as we ſhall have uſe of them; and thoſe may be readily drawn, as I have borrowed of him, in this manner.

Let the outward Circle, repreſenting the Horizon, be drawn and divided into four equal parts, with S N the Meridian, E W the Vertical, and each fourth part into 90 *deg.* That done, lay a Ruler to the Point S, and each Degree in the Quadrant E N, and note the Interſections where the Ruler croſſeth the Vertical; ſo ſhall the Semidiameter E Z be divided into other 90 *deg.* and from thence the other Semidiameters may be divided in the ſame ſort; thoſe may be numbred with 10, 20, 30, from E towards C; and for variety, with 10, 20, 30, from C towards W: But for the Meridian, the South part would be beſt numbered according to the Declination from the Æquator, and the North part according to the Diſtance from the Pole.

Then with reſpect unto the Latitude, which here we ſuppoſe to be 51 *deg.* 30 *min.*

open

open the Compaſſes unto 38 *deg.* 30 *min.* from C toward W, and prick them down in the Meridian from C unto P; ſo this Point P ſhall repreſent the Pole of the World, and through it muſt be drawn all the Hour-circles.

Having three Points E P W, find their Centers, which will fall in the Meridian, a little without the Point S, and draw them in a Circle E P W, which will be the Circle of the Hour of 6.

Through this Center of the Hour of 6 draw an occult Line at length parallel to E W, ſo this Line ſhall contain the Centers of all the other Hour-circles: where the Circles of the Hour of 6 croſſeth this occult Line, there will be the Centers of 9 and 3 their Hour-circles.

The diſtance between theſe Centers of 9 and 3, will be equal to the Semidiameters of the Hour-circles of 10 and 2: where theſe two Circles of 10 and 2 ſhall croſs this occult Line, there will be the Center of 7 and 5. And again, take with your Compaſſes off the Diameter E W 75 *deg.* under W, and turn the Compaſſes three times over on the occult Line, from the Center of the Hour of 6, and you have the Center of the Hours of 1 and 11. Again, take 78 *deg.* from E towards C, and lay it both ways from the Center of the firſt Hour-circle of 6, on the occult Line, and you have the Center of the Hour-circle of 4. So practice for any other Latitude.

The Hour-circles being thus drawn, take 51 *deg.* 30 *min.* from C toward W, and prick them down in the South part of the Meridian from C unto A, and bring the third Point E A W into a Circle; this Circle ſo drawn ſhall repreſent the Æquator.

The Tropick of *Cancer* is 23 *deg.* 30 *min.* above the Æquator, and 66 *deg.* 30 *min.* diſtant from the Pole; and ſo in this Latitude it will croſs the South part of the Meridian at 28 *deg.* from the Zenith, and the North part of the Meridian 15 *deg.* below the Horizon. Take therefore 28 *deg.* from C towards W, and prick them down in the Meridian from C unto D, ſo have you the South Interſection: Then lay the Ruler to the Point W and 15 *deg.* in the Quadrant N W, numbred from N toward W, and note where it croſſeth the Meridian; ſo ſhall you have the North Interſection. The half-way between theſe two Interſections in the Meridian Line is the Center of the Tropick of *Cancer*: Which being truly drawn, will croſs the Horizon before 4 in the Morning, and after 8 in the Evening, about 40 *deg.* Northward from E and W, according to the riſing and ſetting of the Sun at his entrance into *Cancer*.

The Tropick of *Capricorn* is 23 *deg.* 30 *min.* below the Æquator, and 113 *deg.* 30 *min.* diſtant from the North Pole; ſo that in this Latitude it croſſeth the South part of the Meridian at 75 *deg.* from the Zenith, and the North part of the Meridian at 62 *deg.* below the Horizon. Take therefore 75 *deg.* towards W, and prick them down in the Meridian from Z unto ♑; ſo have you the South Interſection: Then lay the Ruler to the Point W, and 62 *deg.* in the Quadrant N W, numbred from N towards W, and note where it croſſeth the Meridian, ſo ſhall you have the North Interſection: the half way ſhall be the Center, whereon you may deſcribe the Tropick of *Capricorn* ♑. This Tropick will croſs the Horizon after 8 in the morning, and before 4 in the Evening, about 40 *deg.* Southward from E and W, according to the riſing and ſetting of the Sun at his entrance into *Capricorn*. Now we will proceed to draw the Hour-lines in a North Recliner and a South Incliner, and ſhew the Height of the Stile above the Plane on the Meridian, and a South Recliner, and a North Incliner; and ſo in order to the reſt.

CHAP. XV.

How to make a North and South Reclining Dial.

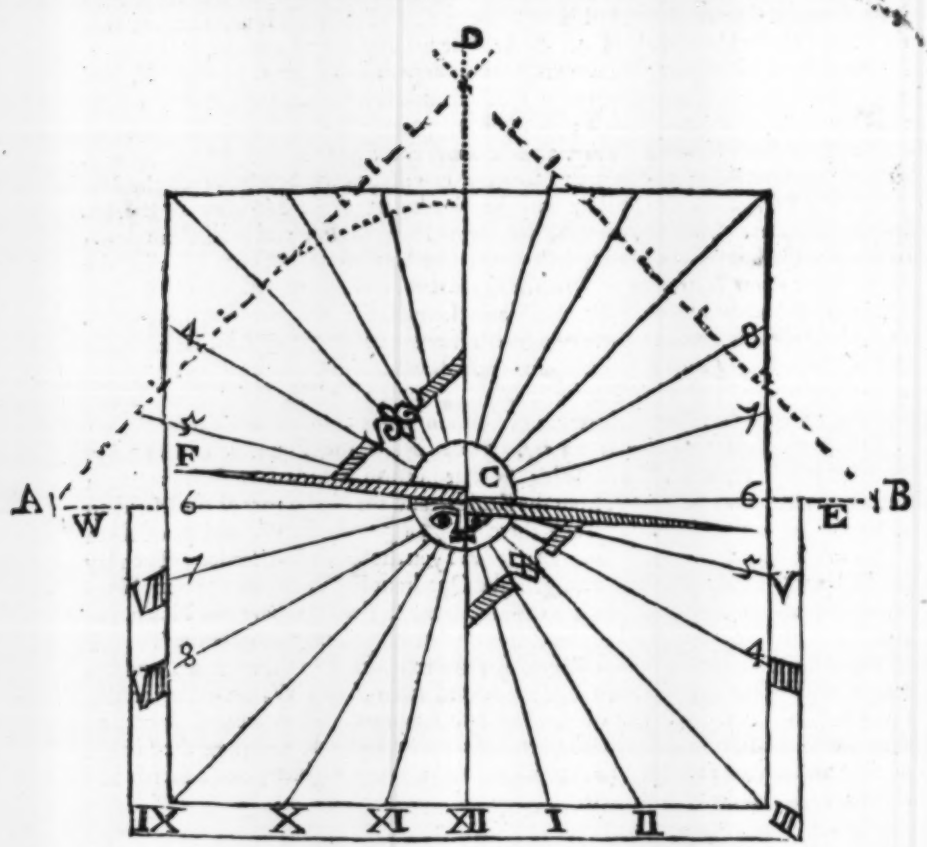
THE Baſe or Horizontal-line of ſuch a Dial lieth in the Eaſt Azimuth, and his Pole in the Meridian, as you may ſee *Chap.* 14.

The Plane of the 14 *Chapter* was a North Plane reclining Southward 45 *deg.* the Zenith is diſtant from the North Pole 38 *deg.* 30 *min.* the Complement

of the Latitude 51 *deg.* 30 *min.* toward the South, and I ſee the Reclination is 45 *deg.* more Southward, becauſe I ſee my Plane reclines ſo much that way. I add the Complement of the Latitude 38 *deg.* 30 *min.* and the Reclination 45 *deg.* together, and I ſee then by the ſame the North Pole is elevated 83 *deg.* 30 *min.* which is the Height of the Stile above the Plane on the Meridian; which 83 *deg.* 30 *min.* taken off the Gnomon Line of the Scale, you may proceed and draw the Dial, and lay that on the Line W E, and work as you did in the other Dials.

The oppoſite face to this is the South Incliner; and if you would draw it, do but prolong thoſe Hour-Lines, as was ſaid in *Chap.* 13. and you have the South Recliner below the Horizontal Line W E.

Note, Had this Reclination been 51 *deg.* 30 *min.* and the Complement of the Latitude added to it would have made 90 *deg.* then it would have fallen into the Plane of the Æquinoctial, and ſo the Dial would have been a Polar Dial, and all the Hours would have had equal ſpaces, and the Gnomon would have ſtood perpendicular, which are the properties of a Polar Dial, as hath been ſhewed *Chap.* 5.



d.	*m.*
51	30
45	00
6	30

As for the South reclination, which is 45 *deg.* which ſubſtract from the Latitude 51 *deg.* 30 *min.* and you have the height of the Gnomon or Stile above the Plane, which by reaſon the Hour-lines will be ſo neer together, continue them, and cut them off as they may fit your Plane, by leaving out one of the Hours, or more, as you will; ſo will you have the Stile a handſom height above the Plane, and the Hour-circles a good diſtance aſunder: But for the North Incliner, his Lines and Stile muſt be drawn from the Center of the Plane, although they do come neer. If the Reclination had been 31 *deg.* then you ſhould have ſubſtracted the Reclination from the Latitude 51 *deg.* 30 *min.* and the Remainder would have been 20 *deg.* 30 *min.* the Height of the Stile or Gnomon above the Plane.

d.	*m.*
51	30
31	
20	30

CHAP.

CHAP. XVI.

How to make an Eaſt or Weſt Reclining or Inclining Dial.

AS it hath been ſhewn *Chap.* 15. That the Baſe or Horizontal-line of a South Recliner lieth always in the Eaſt Azimuth; ſo the Baſe of an Eaſt Recliner lieth always in the Meridian of the Place: And as all Declining Planes lie in ſome Azimuth, and croſs one another in the Zenith and Nadir, by *Chap.* 13. So theſe Reclining Planes lie in ſome Circle of Poſition, and croſs one another in the North and South Points of the Horizon; which being conſidered; theſe Eaſt Recliners, Weſt Incliners, and Weſt Recliners, and Eaſt Incliners, ſhall be made as eaſily as the former.

For theſe Eaſt Recliners be in very deed South Decliners to thoſe that live 90 *deg.* from us Northward or Southward, and have one of thoſe Poles elevated as much as the Complement of our Latitude; for the Perpendicular or Plumb-line of thoſe People is parallel to the Horizontal Diameter of our Meridian.

EXAMPLE.

I Have an Eaſt Plane reclining 45 *deg.* which I would make a Dial.

In the former Diagram I number 45 *deg.* from E to F, and then lay a Ruler from N to F, and it will cut the Semidiameter Z W in 45 *deg.* in V. And then draw the Arch S V N, which Circle ſhall repreſent the Plane propoſed.

Then the Arch of the Plane between the Horizon and the Subſtiler Diſtance is repreſented in the Diagram by N Q, and may be found by reſolving the Triangle Q N P, wherein the Angle at Q is known to be Radius, and the Angle at N to be Reclination, and the Angle at P the Latitude: Then work thus.

As the Radius or Sine of 90 *deg.* Q	1000000
Is to the Sine of Reclination 45 *deg.* N	984948
So is the Tangent of the Latitude 51 *deg.* 30 *min.* P N	1009939
To the Tangent of the Subſtile Q N 41 *deg.* 38 *min.*	994887

Or upon *Gunter*'s Ruler, Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 45 *deg.* the ſame will reach from the Tangent of the Latitude 51 *deg.* 30 *min.* to near 41 *deg.* 38 *min.* as before, in the Line of Sines; and ſuch is the Subſtiler diſtance.

Secondly, The Height of the Pole above the Plane may be repreſented by the Arch P Q, and may be found, by which we have given in the Triangle Q N P: For,

As the Sine of 90 Q	1000000
To the Sine of 51 *deg.* 30 *min.* P N	989354
So is the Sine of Reclination 45 *deg.* N	984948
To the Sine of the Stiles Height 33 *deg.* 36 *min. or Pole above the Plane* P Q	974302

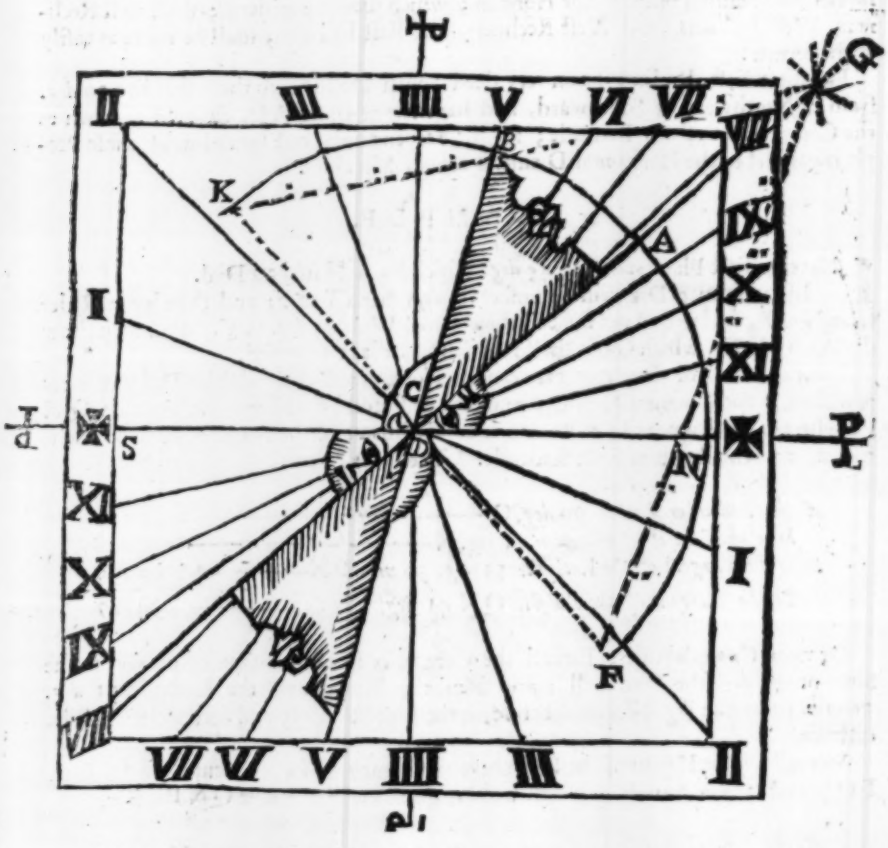
Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 51 *deg.* 30 *min.* the ſame Extent will reach from the Sine of Reclination 45 *deg.* to 33 *deg.* 36 *min.* as before, which is the Height of the Stile.

Thirdly, The Inclination of Meridians (or indeed you may call it Longitude) is here repreſented by the Angle P Q N; for having drawn the Arch of the Meridian of the Plane S Q N, or let fall a Perpendicular P Q, and that from the Pole unto the Plane, this Perpendicular ſhall be the Meridian of the Plane; ſo that from Q to N is the Diſtance of Inclination of both Meridians, which will be found as before: For,

As the Sine of 51 *deg.* 30 *min.* P N—————— 989354
To the Sine of 90 *deg.* Q—————— 1000000
So is the Sine of the Subſtiler Diſtance 41 *deg.* 38 *min.*
To the Sine of Inclination of both Meridians—————— 971594

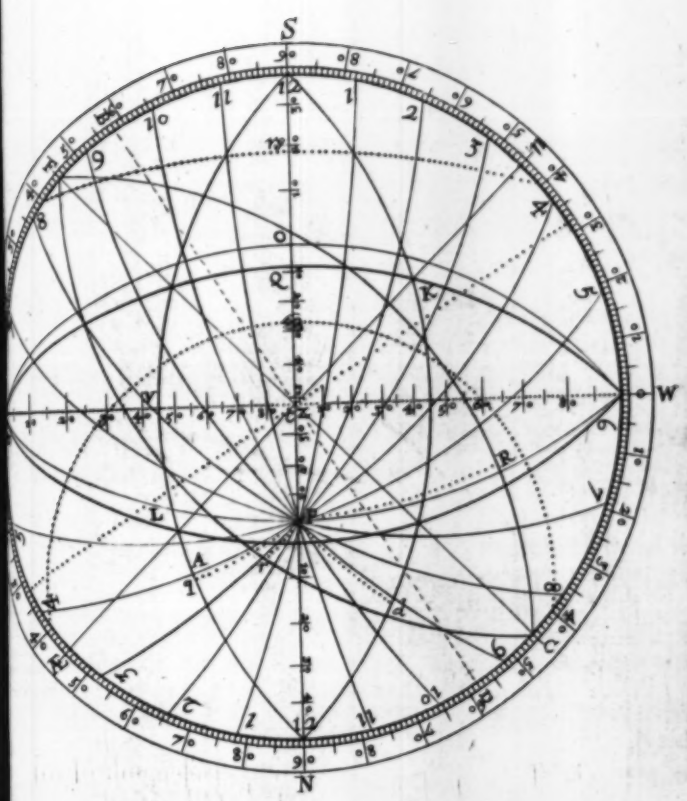
which will be found to be 58 *deg.* 40 *min.* N P Q.

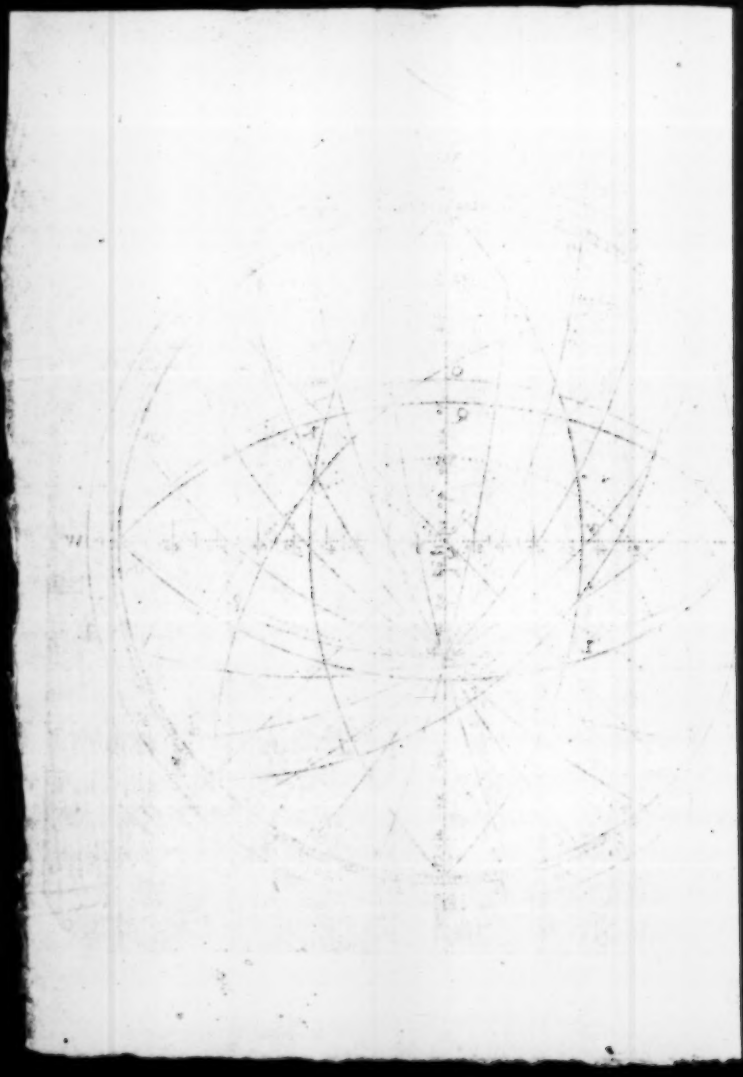
Extend the Compaſſes from the Sine 51 *deg.* 30 *min.* to the Sine of 90; the ſame Extent will reach from 41 *deg.* 38 *min.* the Subſtiler Diſtance, to 58 *deg.* 40 *min.* and ſuch is the Angle P Q N of the Inclination, between the Meridian of the Place and the proper Meridian of the Plane: which reſolved into time, doth make about 3 *ho.* 54 *min.* and ſo the Subſtiler muſt be placed neer the Hour of 8 in the morning.



For to draw the Hour-lines on the Plane, firſt draw the Horizontal-line S N: Then take off your Line of Chords with your Compaſſes the Chord of 60 *deg.* from your Scale, and ſweep the Semicircle: Then take off your Line of Chords with your Compaſſes the Subſtiler Diſtance, and lay it from N on the Arch to A; Then draw through the Center aud A in the Arch, the Subſtiler Line, croſſing it in the Center at Right Angles with the Line K F: Then take off with your Compaſſes the Height of the Pole above the Plane, or the Stiles Height 33 *deg.* 36 *min.* from the Gnomon Line of the Scale, and lay it from the Center of the Dial both ways from K to F. Then take the whole Line of 6 Hours, and ſweep the two ſmall Arches from K towards G, and the like from F toward G: Then draw the Lines K G and F G: Then extend the Compaſſes from G to N, and apply it to the Hour-line, and you ſhall find the Inclination of Meridians to be as before 3 *ho.* 54 *min.* Then take 4 *ho.* 54 *min.* and lay it to O, and the ſame Diſtance from K unto O toward G; and the like do with 2 *ho.* 54 *min.* and make ſuch marks on the Line G F and K G as you ſee in the Figure to

draw


S
W
N

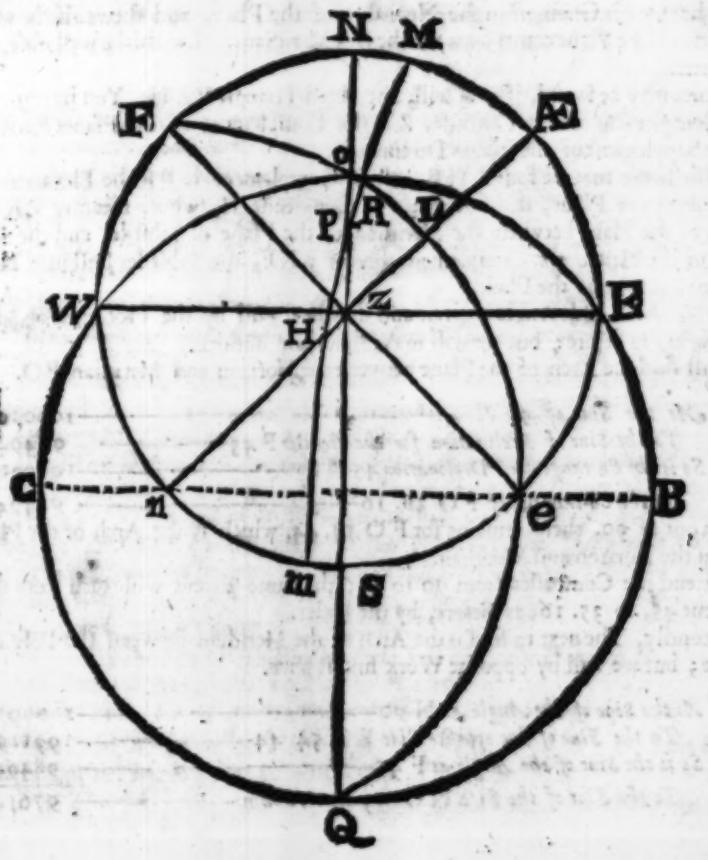


draw the Hour-lines by; and then take off the Line of Chords 33 *deg.* 36 *min.* the Stiles Height, and lay from A to B, ſo drawing the Hour-lines, and you have done. And then you may ſee as in a Glaſs the Weſt Recliner, the oppoſite Face, as you were ſhew'd before *Chap.* 13. that is, ſtrike the Subſtiler Line, and all the Hour Lines through the Center, and the ſame Figures to every Hour beyond the Center, which you had on the firſt ſide, and ſet the Gnomon upon the Subſtile downwards, to behold the South Pole, and you have done both: So have you on the back ſide, looking through the Paper, the Weſt Recliner and Eaſt Incliner, if you draw in the like manner, or prick on the back ſide, for 11 in the Eaſt 1 in the Weſt Recliner, and ſo contrarily of the reſt.

CHAP. XVII.

How to find the Arches and Angles that are requiſite for the making of the Reclining Declining Dial.

BEfore you can intelligently make a Reclining Declining Dial, which is the moſt irregular of al, having two Anomalies, *viz.* Declination and Reclination, you muſt be acquainted with thoſe three Triangles in the Sphere, wherein certain Arches and Angles lie, which are needful to be known. I adviſe you firſt to draw, though it be but by aim, an Horizontal Projection of the Sphere, ſuch as here I have drawn for a South declining Weſt 45 *deg.* and reclining from the Zenith 45 *deg.* in the Latitude of 51 *deg.* 30 *min.* which ſhall be our Example. The ſame alſo is ſhewed in the Fundamental Diagram; only I ſhew you this, to let you know, there is ſeveral ways to the Wood beſides one.



In

In this Figure the Arch F L ☌ is the Plane, Z L the Reclination thereof, F E the Base or Horizontal Line of the Plane, and Æ n the Vertical of the Plane, cutting it right at L, and cutting the Pole thereof at H: for n is the Pole of a Plane erected upon F E; but the Pole of the Reclined Plane F L E is H n Æ; or S n is the Declination of the Plane, P H m the Meridian of the Plane, cutting the North Pole at P, the Plane at Right Angles at R, and the Pole thereof at H.

In the first Triangle F N O you have given F N 45 *deg.* the Complement of the Planes Reclination N, the Right Angle of our Meridian with our Horizon F, the Complement of Reclination 45 *deg.* whereby you may find F O the Oblique Ascension, or the Arch of the Plane between the Horizon and our Meridian, that is, how many Degrees the Noon-line shall lie above the Horizontal-line. Also you may find N O the Perpendicular Altitude of the Noon-line, or the Inclination of the Noon-line of the Dial to the Horizon, which taken out of 51 *deg.* 30 *min.* remains the Arch of the Meridian between the Pole and the Plane. But note, That when this Altitude of the Noon-line N O is equal to N P the Elevation of the Pole, then is the second Triangle P R O quite lost in the Point P, and the Plane becometh then a Declining Æquinoctial Plane: Also you may find the Angle at O, called the Angle of Inclination between the Meridian and the Plane. In the second Triangle O R P you have given O as before, R the Right Angle of the Plane with his Meridian, O P the Position Latitude, that is, the Latitude of the Place wherein the Reclining Plane O R L E Q shall be a Circle of Position; this is given if you substract N O, the Altitude of the Noon-line, as before, out of the Latitude; and hence may be found O R the Declination of the Gnomon or Substilet Distance, or Distance of the Meridian of the Plane from the Meridian of the Place; R P the Elevation of the Pole above the Plane, in the Planes own Meridian or Stiles Height; P the Angle between the Meridian of the Plane, and the Meridian of the Place. This Angle is called the Difference of Longitude, because it shews how far the Places are distant from us in Longitude; wherein this Dial shall be a Direct Dial, without Declination, having his Gnomon in the Noon-line of the Place, and shews also how many Degrees of the Plane comes between the said Meridians. Let this be well observed by Learners.

Hence may be found, if you will, the third Triangle P Z H: You have given P Z the Complement of our Latitude, Z H the Complement of the Planes Reclination, Z the Supplement of the Planes Declination.

Also hence may be found H P, whose Complement is P R the Elevation of the Pole above the Plane, the Difference of Longitude H, whose measure is R L, the Arch of the Plane between the Meridian of the Plane or Substile, and the Vertical Line of the Plane; the Complement thereof is R F, the Substiles Distance from the Horizontal Line of the Plane.

Every Arch and Angle is given and may be found by the Problems of Spherical Triangles, as before; but we will make short our business.

First find the Arch of the Plane between the Horizon and Meridian F O.

As the Sine of 90 N	1000000
To the Sine of Reclination for the Zenith F 45	984948
So is the Co-tangent of Declination 45 N F	1000000
To the Co-tangent of F O 36. 16	984948

taken out of 90, there remains for F O 54. 44. which is the Arch of the Plane between the Horizon and Meridian.

Extend the Compasses from 90 to 45; the same Extent will reach from the Co-tangent 45, to 35. 16, as before, by the Ruler.

Secondly, The next to find is the Arch of the Meridian between the Pole and the Plane; but we will by opposite Work find it thus.

As the Sine of the Angle at N 90	1000000
To the Sine of his opposite Side F O 54. 44	991194
So is the Sine of the Angle at F 45	984948
To the Sine of the Side N O 35 *deg.* 16 *min.*	976142

Or,

Or, Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 54 and 44; the ſame Extent will reach from the Sine of 45 *deg.* to 35. 16 NO, which Subſtracted from the Latitude 51 *deg.* 30 *min.* remains the Arch of the Meridian between the Pole and the Plane OP 16 *deg.* 14 *min.*

Thirdly, Now you muſt find the Angle NOF, which will be ROP, which is called the Angle of Inclination between the Meridian and the Plane, thus:

As the Sine of FO 54. 44	008805
To the Radius or Sine of 90	1000000
So is the Sine of the Side FN 45	984948
To the Sine of the Angle ROP 60. 0.	993753

Extend the Compaſſes from the Sine of 90, to the Sine of 54. 44; the ſame Extent will reach from the Sine of 45, unto 60. as before-found, the Angle of Inclination between the Meridians and the Plane.

Fourthly, The next to be found is the Subſtile Diſtance, or the Meridian of the Plane from the Meridian of the Place.

As the Sine of the Angle at R 90	1000000
To the Co-ſine of the Angle at O 30. 0	969897
So is the Side of the Tangent PO 16. 14	946412
To the Tangent of the Subſtile OR 8 *deg.* 17 *min.*	916309

And thus extend the Compaſſes from the Sine of 90 *deg.* to the Co-ſine of 30 *deg.* the ſame Diſtance will reach from the Tangent of 16. 14, to the Tangent of the Subſtile from the Meridian 8 *deg.* 12 *min.*

Fifthly, Next find the Elevation of the Pole above the Plane or Stiles Height: For,

As the Sine of 90 *deg. at* R	
To the Sine of his Oppoſite PO 16. 14	944645
So is the Sine of the Angle at O 60	993753
To the Sine of the Stiles Height above the Plane 14. 1	438398

Or, Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 16 *deg.* 14 *min* the ſame Diſtance will reach from the Sine of 60 the Angle at O, to the Height of the Pole above the Plane 14 *deg.* 1 *min.* or Stiles Height, as before.

Sixthly, Now for the Difference of Longitude or Angle at P, or Inclination of the Meridian of the Plane to the Meridian of the Place, it is thus.

As the Sine of the Arch PO 16. 14	944645
Is to the Sine of 90 *deg.* R	1000000
So is the Sine of the Subſtile Diſtance 8 *deg.* 17	915856
To the Angle at P *or Difference of Longitude* 31 *deg.* 1 *min.*	971211

Extend the Compaſſes from the Sine of 16 *deg.* 14 *min.* to the Sine of 90 *deg.* the ſame Extent will reach from the Subſtile Diſtance 8 *deg.* 17 *min.* for the Inclination of both Meridians 1 *hr.* 4 *min.* as before.

Seventhly, The Diſtance of the Hours from the Subſtiler are here alſo repreſented by thoſe Arches of the Plane which are interſected between the proper Meridian and the Hour-circles. The Angle at R, between the Pole and the proper Meridian, is a Right Angle; the Side RP is the Height of the Pole above the Plane; and then the Angles at the Pole between the proper Meridian and the Hour-circles may be gathered into a Table: For,

As the Sine of 90 R,
To the Sine of the Height of the Pole above the Plane 14. 1.
So is the Sine of the Angle at the Pole 16. 14.
To the Sine of the Hour-line from the Subſtiler 3 *deg.* 50 *min.*

Extend the Compaſſes from the Sine of 90, to the Sine of 14. 1; the ſame Extent will reach from 16. 14, to 3 *deg.* 50 *min.*

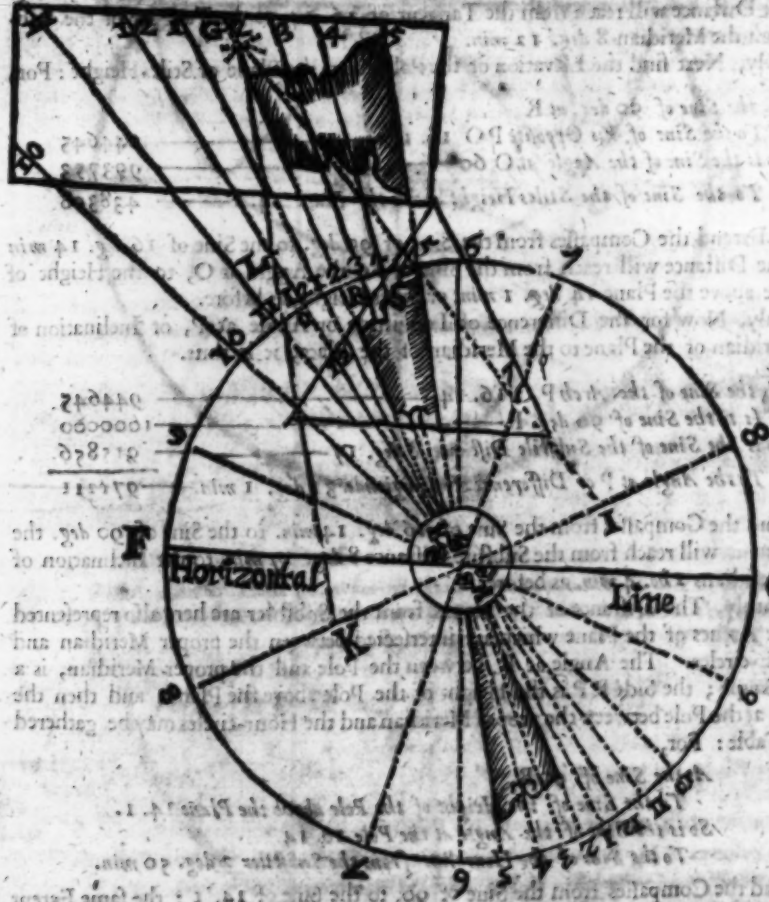
The Arch of the Plane between the Horizon and the Meridian F O 54 *deg.* 44.
The Arch of the Meridian between the Horizon and the Plane O N 35. 16.
The Angle of Inclination between the Meridian and the Plane F O N 60.
The Subſtile Diſtance from the Meridian O R 8 *deg.* 17 *min.*
The Height of the Stile above the Plane P R 14 *deg.* 1 *min.*
The Inclination of both Meridians or Angle at P 31 *deg.* 1 *min.*
The Difference of the Hour from the Subſtile 3 *deg.* 50 *min.*

CHAP. XVIII.

How to draw the Reclining Declining Dial.

NOte, You have got the three principal Arches for the drawing the Hours.
1. The Arch of the Plane between the Horizon and the Meridian 54 *deg.* 44 *min.*
2. The Subſtile Diſtance from the Meridian of the Place O R 8 *d.* 17 *m.*
3. The Height of the Pole above the Plane or Stiles Height P R 14 *d.* 1 *m.*

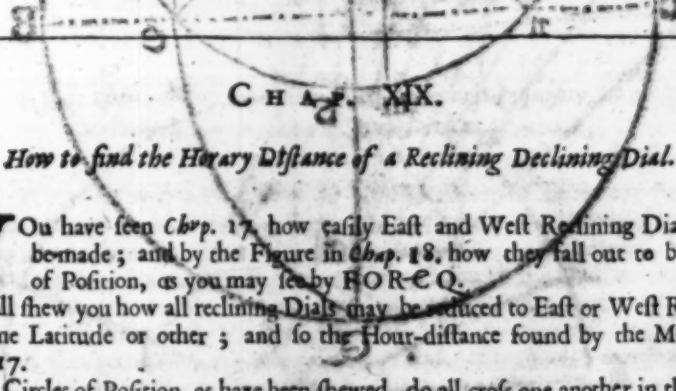
How to draw the South declining Weſt 45 *deg.* and reclining from the Zenith 45 *d.* is thus. Firſt draw the Horizontal Line F e, with your Compaſſes take off the Scale and Line of Chords the Radius 60 *deg.* and ſweep the Circle F O R P e; then take



off the ſame Line of Chords 54 *deg.* 44 *min.* the Arch of the Plane between the Horizon and the Meridian, and lay it from F on the Arch to O: Then take off your Line

of

of Chords 8 *deg.* 17 *min.* the Substile Distance, and lay it from O to R; then from the Center draw the Substile Line CG; then take of the Quadrant 90 *deg.* of the Line of Chords, and lay it both ways from R to M and N, and draw that obscure Line; then take off the Poles Height above the Plane or Stiles Height 14 *deg.* 1 *min.* from the Gnomon Line of the Scale, and lay it both ways from C to K; and then with your Compasses take off your Scale the whole Line of 6 Hours, and from K toward G, and from I toward G, strike the two small Arches; then draw the Lines KG and IG; then extend the Compasses from G to the Meridian Line at L, and apply that Distance to your Scale and Hour-line, and you will find it to be 2 *ho.* 4 *m.* which is the Inclination of Meridians or Angle at P, as before: Then lay that Distance from L toward G, and take (as before directed in *Chap.* 17.) one Hour less, and lay it off in the same manner from G toward K, and from I toward G; and the like do with 3 *ho.* 4 *min.* until you have put all the 6 Hours on the Line from G to K, and from I to G: Then draw the Hour Lines according to your Plane, whether it be a Triangle, or Circle, or Square, or what shape soever; then lay off the Height of your Stile 14 *deg.* 1 *min.* from R to P, taken off the Line of Chords, and draw it from the Center, and cut it fit to your Plane in what shape you will, as you may see in the Figure, and your Dial is done. The opposite Face or Incliner to the Horizon is but to continue the Stile and Substile and Hour-lines through the Center, as you may see, and you have it. In like manner you may draw the South East Decliner 45 *deg.* and Reclining from the Zenith 45 *deg.* if your once draw on Paper this before, and the Hour-lines over the same, and the like the Substile, and the Stile to stand upon the Substile upright, as of the rest. And let the highest part of the Stile be towards the North Pole, pointing upwards; and where the Hour of 10 is in the South West Recliner, on the back side put 2 a clock, and for 11 put 1, and for 1 put 11, and for 2 put 10, and so contrary all the rest. And if you observe your Work, you have the South West and the South East Recliners, and the North West and North East Inclines; or you may draw them by what was given in the first, in the same manner.



CHAP. XIX.

How to find the Horary Distance of a Reclining Declining Dial.

YOu have seen *Chap.* 17. how easily East and West Reclining Dials are to be made; and by the Figure in *Chap.* 18. how they fall out to be Circles of Position, as you may see by HORCQ.

I will shew you how all reclining Dials may be reduced to East or West Recliners, for some Latitude or other; and so the Hour-distance found by the Method of *Chap.* 17.

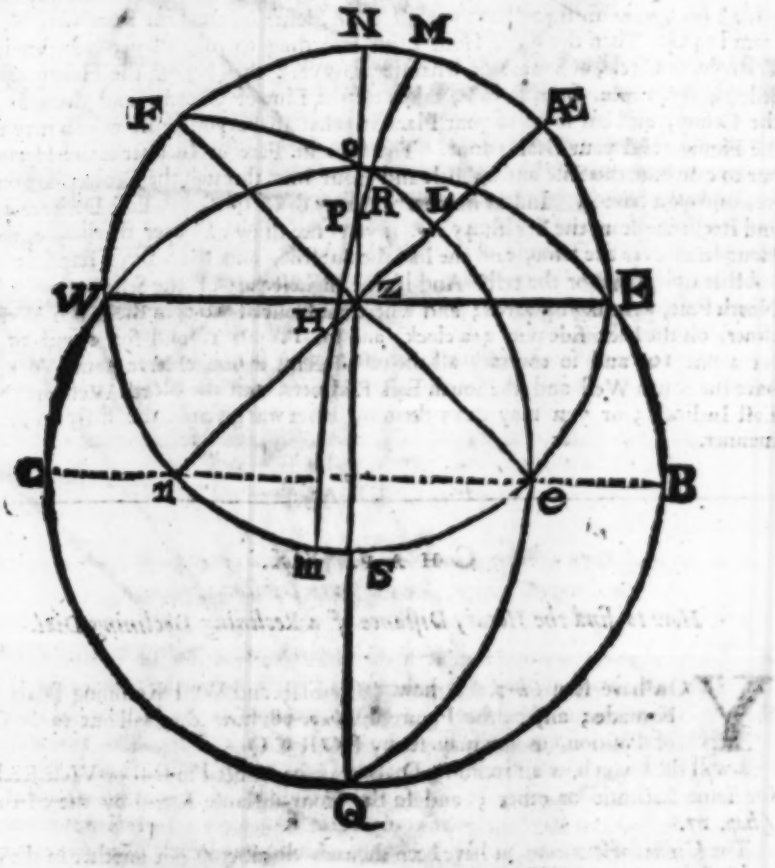
The Circles of Position, as have been shewed, do all cross one another in the North and South Points of the Meridian: Now therefore by the Point O, where the Plane cuts our Meridian, draw a new Horizon, as OBQC, and then shall you see your Plane in that Horizon to be a very Circle of Position.

But now we are gotten into a new Latitude OP, called before *Chap.* 18. the Position Latitude; and we have here a new Reclination: for whereas this Plane reclineth in our Latitude ZFL 45 *deg.* his Position Reclination is O, *viz.* ZOL or POR 60 *deg.* In the making of this Dial therefore you shall forget your own Latitude, and the Planes Reclination in your Horizon; and with this new Latitude and Reclination make the Dial after the manner of the East Recliner, *Chap.* 17. not regarding the Declination at all: for the Base of this Plane is now fallen into the Horizontal Line of the Meridian; and his Declination being a Quadrant, he is become a Regular Plane, and neither his Declination nor Reclination shall much trouble you.

How to place your Noon-line from the Horizontal or Vertical Line of the Plane, you have found already.

Note, Your new Latitude is PO 16 *d.* 14 *m.* then you know your Plane is the 60 *d.* Azimuth from the Axis, becauſe POR is 60 *deg.* as before 90 *deg.* farther from the ſaid Azimuth you have the Pole of the Plane, and therefore is the Meridian of my Plane, and ſhall make the Subſtile of my Dial OPR 3 *deg.* 1 *min.* his Diſtance from the Meridian of the Place in that Æquinoctial, and is therefore the Difference of Longitude, as before.

Then have you the Side P R the Height of the Stile 14 *deg.* 1 *min.* or Elevation of the Gnomon, as before: Likewiſe have you O R the Declination or Subſtile Diſtance from the Meridian 8 *deg.* 17 *min.* as before, and you may proceed to draw the Dial in like manner as you have been directed in *Chap.* 16.



CHAP. XX.

To draw the Proper Hours of any Declining Dial.

EVery declining Plane, whether it recline or not, hath two great Meridians much ſpoken of.

1 The Meridian of the Plane, which is the proper Meridian of that Country to whoſe Horizon the Plane lieth Parallel.

2 The Meridian of the Place, which is the Meridian of our Country in which you ſet up this Declining Plane, to ſhew the Hours; and ſo either of theſe Meridian Dials may be conformed.

How to draw the Hours of our Country on ſuch a Plane, is the harder work, becauſe

cauſe the Plane is irregular to our Horizon: yet I ſuppoſe I have made the way very eaſie in the former Chapters. But to draw the Hours of the Country to which the Plane belongs, is moſt eaſie; for if you take the Subſtiler for the Noon-line, and the Elevation of the Pole above the Plane for the Latitude, you may make this Dial in all points like the Vertical Dial, after the Precept of *Chap.* 8.

CHAP. XXI.

To know in what Country any Declining Dial ſhall ſerve for a Vertical.

IF the Dial decline Eaſt, add the Difference of Longitude found in *Chap.* 13. & 18. to the Longitude of the Place, and the ſum or the exceſs above 360 is the number of the Longitude ſought. If the Dial decline Weſt, ſubſtract the ſaid Difference of Longitude out of the Longitude of your Place, and the Difference is the Longitude inquired: but when the Longitude of your place happens to be leſs than the Difference of Longitude, you muſt add to it 360 *deg.* before you ſubſtract the Difference of Longitude. Note, The Elevation of the Pole above the Plane, or Stiles Height, is the Latitude of the Place inquired.

Example. The Declining Plane of *Chap.* 13. will be a Vertical Plane in the Longitude of 66 *deg.* 46 *min.* in the Deſarts of *Arabia* neer *Zoar*: and the declining reclining Plane of *Chap.* 18. & 19. is parallel to the Horizon of thoſe that ſail in Longitude 357 *deg* 41 *min.* and North Latitude 14 *deg.* that is, as the Terreſtrial Globes and Maps ſhew me, between *Bonaviſta*, one of the *Cape Verd* Iſlands, and *Barbadoes*.

CHAP. XXII.

How to find the Arches and Angles which are requiſite in a North Decliner Recliner, and a South Decliner Incliner.

I Could not paſs by this Example of the North Recliner Decliner, and South Incliner Decliner, although it is ſhewed in the Fundamental Diagram; but it may be too obſcure, and harder to be apprehended by the Induſtrious Practitioner there; therefore I would adviſe him to draw a Scheme of the Dial, as was ſhewed *Chap.* 15. & 18. or draw the Fundamental Diagram in Paper, and with a ſmall Needle prick the Hour-lines, Horizon, and Meridians, Æquinoctial, and the Tropicks; and then you have a Figure ready to be ſtamped with a little Charcoal-duſt as often as you have occaſion: Or if you apprehend your Work in any manner, the Figure following, or the like, may ſerve your turn, to ſhew you the Angles you are to find, and Arches for the making of your Dial. I ſhall be ſhort in this, and refer you to *Chap.* 15. & 18.

The Circle E S W N is our Horizon, as before; N S our Meridian, F L C the Plane, Z L the Reclination thereof, F C the Baſe or Horizontal Line of the Plane, Æ N the Vertical of the Plane, cutting it right at L, and cutting the Pole thereof at H: for N is the Pole of a Plane erect upon F C; but the Pole of the Reclining Plane F L C is H; S E or n N the Declination of the Plane.

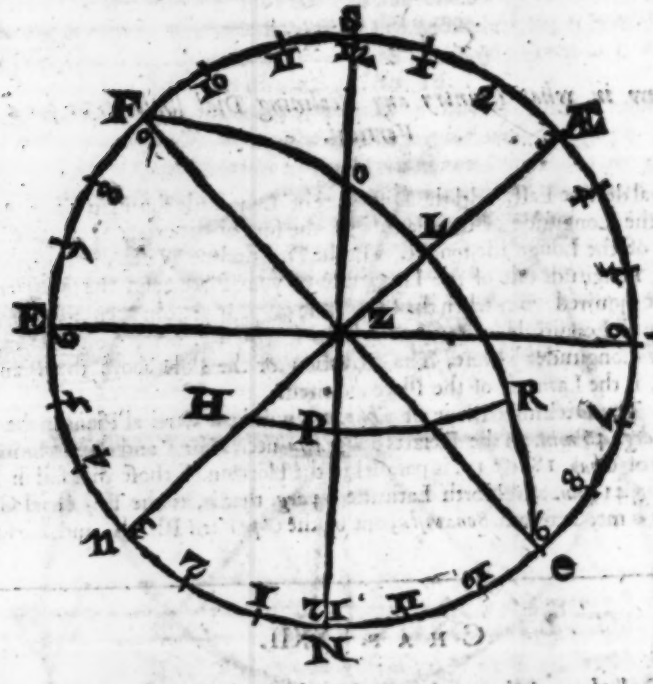
Now you ſee your three Triangles all adjoyning in this Scheme, *viz.* F S O and O R P rectangled at S and R, and P Z H obtuſe angled at Z.

It is true, That the two firſt may do the Work, and ſo we will be brief. Obſerve, you are to find as followeth.

1. The Arch between the Horizon and the Plane F O.
2. The Arch of the Meridian between the Horizon and the Plane S O.

3. The

3. The Arch of the Meridian between the Pole and the Plane P O.
4. The Angle of Inclination between the Meridian and the Plane F O S.
5. The Angle of Inclination between both Meridians O P R.
6. The Subſtile Diſtance from the Meridian O R.
7. The Height of the Stile above the Plane P R.



1. To find the Arch of the Meridian between the Horizon and the Plane, it is thus.

As the Sine of 90 *at* S	1000000
To the Sine of Reclination at F 45	984948
So is the Co-tangent of Declination F S 45	1000000
To the Complement Tangent of F O 35 *deg.* 16 *min.*	984948

Or thus: Extend the Compaſſes from the Sine of 90, to the Sine of 45; the ſame Extent will reach from the Tangent of 45 *deg.* to the Sine of 35 *deg.* 16 *min.* as before; which ſubſtracted from 90 *deg.* there remains 54 *deg.* 44 *min.* the Arch of the Plane between the Horizon and Meridian F O.

2. To find the Arch of the Meridian between the Pole and the Plane, firſt find the Arch of the Meridian between the Horizon and the Plane S O thus.

As the Sine of 90 *at* S	1000000
To the Sine of the Arch of the Plane between the Horizon and Plane F O 54. 44	991194
So is the Tangent of Reclination at F 45	1000000
To the Tangent of the Arch of the Meridian between the Horizon and Plane S O 39 *deg.* 14 *min.*	991194

Or thus: Extend the Compaſſes from the Sine of 90, to the Sine of 54 *deg.* 44 *m.* the ſame Extent will reach from the Tangent of 45 *deg.* to the Tangent of S O 39 *d.* 14 *min.* by the Tables found before: which 39 *deg.* 14 *min.* taken out of 90 *deg.* there

there remains 50 *deg.* 46 *min.* the Arch of the Meridian between the Zenith and the Plane O Z; which being added to the Complement of the Latitude Z P, there will be 89 *deg.* 16 *min.* for the Arch of the Meridian between the Pole and the Plane P O.

3. For the Angle between the Meridian and the Plane P O S or Z O L, it is

As the Sine of the Arch F O 54 *deg.* 44 *min.*	991194
To the Radius or Sine of 90 *deg.* S	1000000
So is the Sine of the Declination F S 45 *deg.*	98494
To the Sine of the Angle at O 60. 0	993754

Or, by *Gunter's* Rule, Extend the Compasses from the Sine of 54 *deg.* 44 *min.* to the Sine of 90 *deg.* the same Extent will reach from the Sine of 45 *deg.* O, to the Sine of 60 *deg.* 0, the Angle between the Meridian and the Plane.

4. Before we find the Inclinations of both Meridians, or the Difference of Longitude or Angle at P, we will find the Substiler Distance O R.

As the Sine of the Angle at R 90 *deg.*	1000000
To the Co-sine of the Angle at O 60 *deg.*	969897
So is the Tangent of the Side P O 89 *deg.* 16 *min.*	1189279
To the Tangent of the Substile O R 88 *deg.* 32 *min.*	1159176

Extend the Compasses from the Sine of 90 *deg.* to the Sine of 30 *deg.* the same Extent will reach from the Tangent of 89 *deg.* 16 *min.* to the Tangent of the Substile 88 *deg.* 32 *min.*

5. Now for the Inclination of both Meridians, or Difference of Longitude, or Angle at P, it is thus. For,

As the Sine of the Arch P O 89 *deg.* 16 *m.*	999996
To the Radius or Sine of 90 *at* R	1000000
So is the Substiler Distance O R 88 *deg.* 32 *min.*	999985
To the Sine of the Angle of Inclinations between both Meridians 88 *deg.* 45 *min. Difference of Longitude*	999989

Which converted into Hours, by allowing 15 *deg.* to one Hour, 4 Minutes to a Degree will be 3 *h.* 55 *min.* as you may find by the Line of Inclination and Hours on your Scale.

6. For the Height of the Pole above the Plane, or Stiles Height,

As the Radius or Sine of 90 *deg.*	1000000
To the Sine of the Arch P O 89 *deg.* 16 *min.*	999996
So is the Sine of the Angle at O 60 *deg.*	993753
To the Sine of the Stiles Height P R 60 *deg.*	993749

the Height of the Pole above the Plane or Stiles Height. And thus if you observe what was said before in the South Decliners Recliners, and now for the North Decliners Recliners Incliners, you have the Propositions for any sorts of Reclining Declining Inclining Dials, and how to find the Arches and Angles, as before, fitting for the making of them. Now we will proceed and draw the Dial.

CHAP.

CHAP. XXIII.

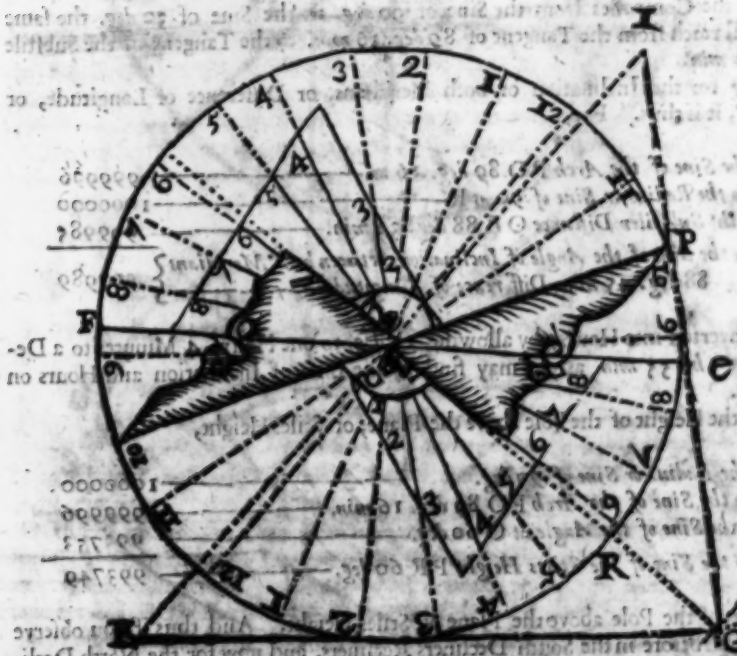
How to draw the Declining Inclining Dial.

AS was ſaid *Chap.* 18. the three principal Arches for drawing the Hour-lines in a South declining Weſt and inclining to the Horizon, and a North Recliner Decliner, as before, or South Eaſt Incliner, or North Weſt Recliner, are theſe three.

1. The Arch of the Plane between the Horizon and Meridian 54 *deg.* 44 F O.
2. The Subſtile Diſtance from the Meridian of the Place 88 *deg.* 32 O R.
3. The Height of the Pole above the Plane, or Stiles Height 60 *deg.* P R.

And ſo follow the Directions of *Chap.* 19. and draw the Dial as you ſee. In what ſhape ſoever the Plane is, proportion the Hours and Subſtile to your Plane, and let the Gnomon or Stile ſtand upright on the Subſtile Line; and ſo have you the lower Face the South Weſt Incliner to the Horizon 45 *deg.* Recliner the like North Face, and declining 45 *deg.* as before, and your Dial is done.

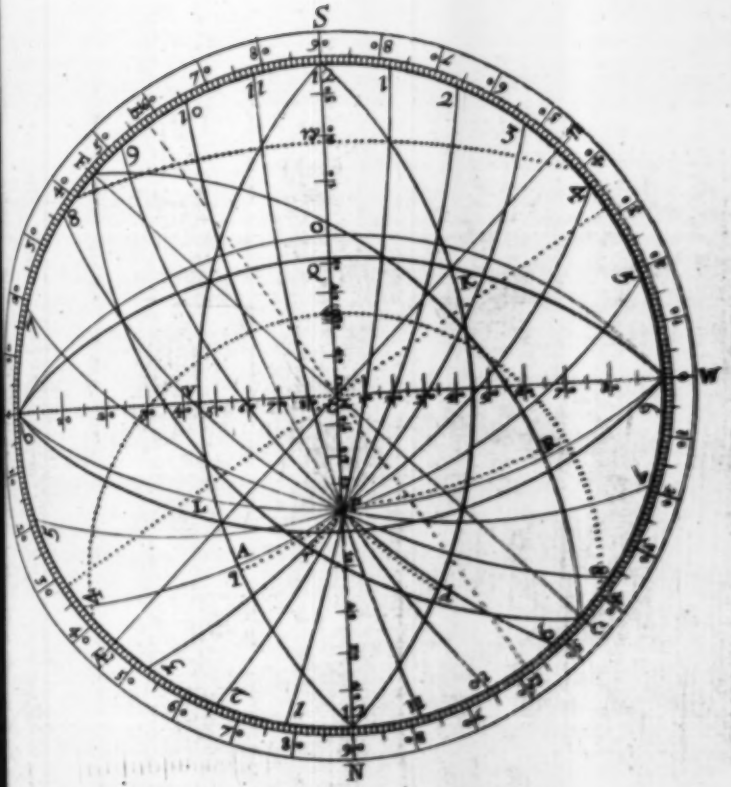
Note, That South Weſt Incliner Recliner is parallel to the Horizon of thoſe that live on the South Land in the South Sea at *Terra viſta Decleros*, in Longitude 297, and South Latitude 60, neer the Straights of *Magellanicum*.



And the North declining Eaſt and Recliner will be parallel to the *Coſſacks*, neer *Tartaria*, in Longitude 114 *deg.* and Latitude North 60 *deg.* as the Globe ſhews me, and I have ſhewed you how to know the like in *Chap.* 21.

And obſerve, The 5 *ho.* 55 *min.* or 88 *deg.* 45 Difference of Longitude, as before, ſhews that the Sun riſes and comes to the Meridian, or 12 a Clock with us at *Briſtol*, 5 *ho.* 55 *min.* before it doth with thoſe Inhabitants in the South Sea, as before: And on the contrary, the Sun is riſen or on the Meridian with the *Coſſacks* to the Eaſtward of us, the like time as the Sun riſes with us before it doth with thoſe of *Terra Viſta Decleros* in the South Sea: So that you ſee of what uſe the Line of Inclination of Meridians on your Scale is, as likewiſe of all Declining Dials.

CHAP.


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W
N

CHAP. XXIV.

How to know the ſeveral ſorts of Dials in the Fundamental Diagram.

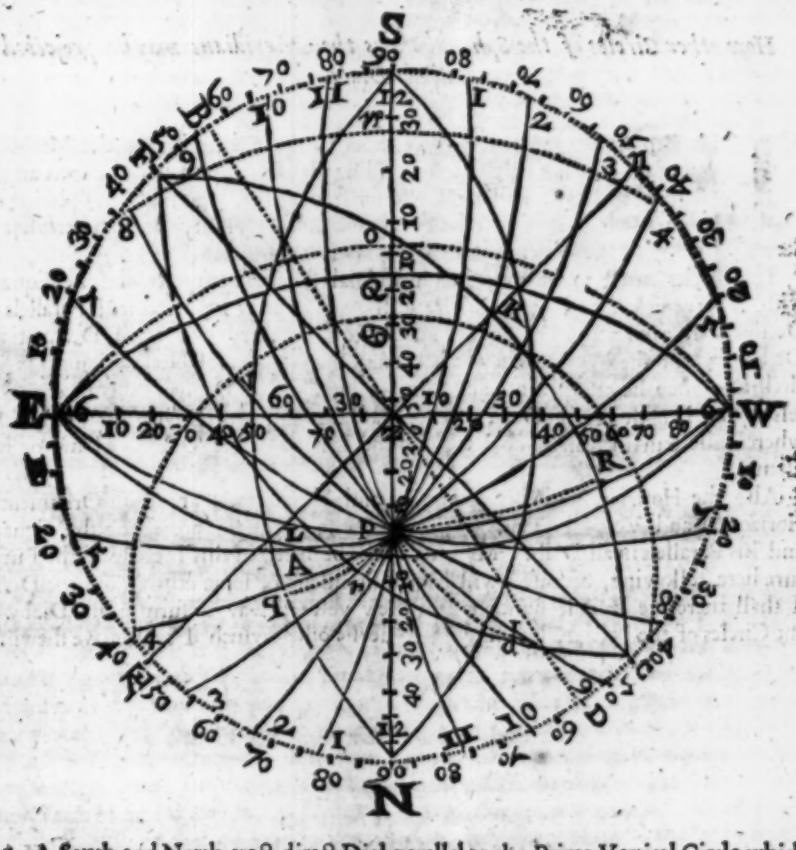
THeſe ſeveral ſorts of Planes take their denomination from thoſe Great Circles to which they are Parallels, and may be known by their Horizontal and Perpendicular Lines, of ſuch as know the Latitude of the Place, and the Circles of the Sphere.

1. An Æquinoctial Plane, parallel to the Æquinoctial, which paſſeth through the Points of Eaſt and Weſt, being right to the Meridian, but inclining to the Horizon, with an Angle equal to the Complement of the Latitude; this here is repreſented by EOW.

2. A Polar Plane, parallel to the Hour of 6, which paſſeth through the Pole and Points of Eaſt and Weſt, being right to the Æquinoctial and Meridian, but inclining to the Horizon, with an Angle equal to the Latitude; this is here repreſented by EPW.

3. A Meridian Plane, parallel to the Meridian the [Circle of the Hour of 12, which paſſeth through the Zenith, the Pole, and the Points of South and North, being right to the Horizon, and the Prime Vertical; this is here repreſented by SZN.

4. An Horizontal Plane, parallel to the Horizon, here repreſented by the outward Circle ESWN.



5. A South and North erect direct Dial, parallel to the Prime Vertical Circle, which paſſeth through the Zenith, and the Points of Eaſt and Weſt in the Horizon, and

is right to the Horizon and Meridian; that is, makes Right Angles with them both: this is repreſented by E Z W.

6. A South Declining Plane Eaſtward is repreſented by B D.

7. A South Incliner and North Recliner is repreſented by E Q W.

8. The South Recliner and North Incliner is repreſented by E A W.

9. A Meridian Plane, which is the Eaſt and Weſt Inclíners and Recliners, and from the Zenith parallel to any Great Circle which paſſeth through the Points of South and North, being right to the Prime Vertical, but inclining to the Horizon; this is repreſented by S V N.

10. A declining, reclining, inclining Plane, which is parallel to any Great Circle which is right to none of the former Circles, but declining from the Prime Vertical, reclining from the Zenith, inclining to the Horizon and Meridian, and all the Hour Circles; this may here be repreſented either by F L C or F K C, or any ſuch Great Circles which paſs neither through the South and North, nor Eaſt and Weſt Points, nor through the Zenith nor the Pole.

Each of thoſe Planes, except the Horizontal, and South inclining 23 *deg.* hath two Faces whereon Hour-lines may be drawn; and ſo there are 19 Planes in all. The Meridian Plane you ſee hath one Face to the Eaſt, and the other to the Weſt: Remember, that it is an Eaſt and Weſt Dial. The other Vertical Planes have one to the South, another to the North; and the reſt, one to the Zenith, and another to the Nadir. What is ſaid of the one, may be underſtood of the other.

CHAP. XXV.

How other Circles of the Sphere beſides the Meridians may be projected upon Dials.

THe Projection of ſome other Circles of the Sphere beſides the Meridians (though it be not neceſſary for finding the Hours, yet) may be both an Ornament to Dials, and uſeful alſo for finding the Meridian, and placing the Dial in its due ſituation, if it be made upon a movable Body, as ſhall hereafter be ſhewed.

The Circles fitteſt to be projected in all Dials for thoſe purpoſes, are, the Equator with his Tropicks, and other his Parallels, which may be accounted Parallels of Declination, as they paſs through equal Degrees, as every 5 or 10 of Declination: Or Parallels of the Signs, as they paſs through ſuch Degrees of Declination as the Sun declineth when he entreth into any Sign, or any notable Degree thereof; or Parallels of the Length of the Day, as they paſs through ſuch Degrees of Declination wherein the Sun increaſeth or decreaſeth the Length of the Day by Hours or half Hours.

Alſo the Horizon, with his Azimuths and Almicantars, are as an Ornament to Horizontal and Vertical Dials, and are likewiſe uſeful for projecting the Equator and his Parallels in all Dials. My intent is to be brief in this Treatiſe of the Furniture here following, becauſe I will have a Preſident of ſome other Country Dials: I ſhall therefore think it ſufficient if I ſhew you one way to furniſh any Dial with the Circles of the Sphere, leaving you to deviſe others which I could have ſhewn.

CHAP. XXVI.

How to deſcribe on any Dial the proper Azimuths and Almicantars of the Plane.

FRom any Point of the Gnomon taken at pleaſure let fall a Perpendicular upon the Subſtile; that Perpendicular ſhall be part of the Axis of the Plane, and ſhall be reputed Radius to the Horizon of your Plane. The top of this Radius in the Gnomon is called *Nodus*, becauſe there you muſt ſet a Knot, Bead, or Button, or elſe cut there a Notch in the Gnomon, to give ſhade; or cut off the Gnomon in the place of the *Nodus*, that the end may give the ſhadow for thoſe Lineaments. Let not your *Nodus* ſtand too high above the Plane, for too great a part of the Planes day; nor let it ſtand too low, for then the Lineaments will run too cloſe together: a mean muſt be choſen.

At the foot of this Radius take your Center and deſcribe a Circle of the Plane, and divide it into equal Degrees, and from the Center draw Lines through thoſe Degrees infinitely, that is, ſo far as your Dial Plane will bear; theſe Lines ſhall be the Azimuths of the Horizon of the Plane, and ſhall be numbred from his Meridian or Subſtile.

Tropicks and other Circles of Declination is ſhewed in Chap. 3. in the Æquinoctial Dial, where they be calculated and drawn by help of a Scale of Equal Parts.

Divide any of theſe Azimuth Lines into Degrees, by Tangents agreeable to the ſaid Radius; and having made a prick at every Degree, through every of theſe pricks you ſhall draw parallel Circles, which ſhall be Almicantars or Parallels of Altitude, to be numbred inwards: ſo that at the Center be 90 for the Zenith, and from the Center outwards you ſhall number 80, 70, 60, until you come within 10 or 5 *deg.* of the Horizon; for the Plane is too narrow to receive its own Horizon, or the Parallel neer, if the Nodus have any competent Altitude.

CHAP. XXVII.

How to deal with thoſe Planes where the Pole is but of ſmall Elevation, and how to enlarge the Stile thereof.

SUch Planes whoſe Stiles or Gnomons lie low, cannot have their Hour-lines diſtinctly ſevered, unleſs the Center of the Dial be placed out of the Plane, as you may ſee in *Chapter* 18. Now to inlarge the Stile in ſuch Dials, there are two Lines or Scales in the large Mathematical Scale, which I call Polar or Tangent Lines of two ſeveral Radius's, the larger of them marked thus ⊻, and the leſſer of them marked ⊷, as you may ſee in the Second Book, *Chap.* 3. The Uſe whereof I ſhall here ſhew you.

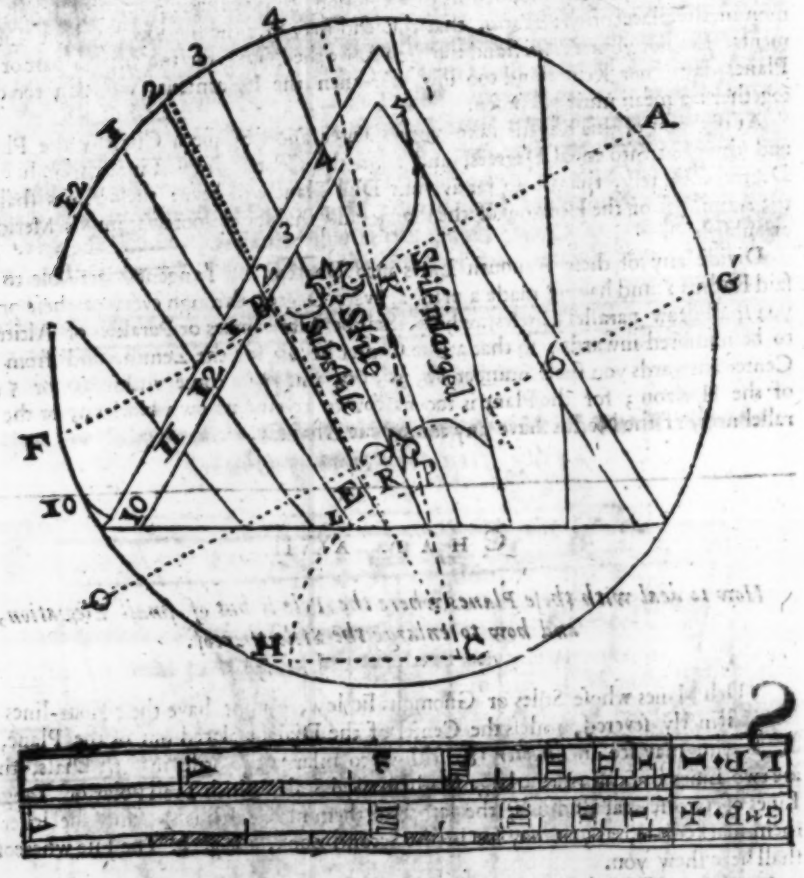
In *Chapter* 18. of this Book there is deſcibed a Plane that declines from the South, Weſtward 45 *deg.* and reclines from the Zenith 45 *deg.* Now ſuppoſe it were required to inlarge that Stile and Dial.

Firſt you ſhall find that there is given the Arch of the Plane between the Horizon and the Meridian, 54 *deg.* 44 *min.* Secondly, The Subſtiler Diſtance from the Meridian to the Subſtile is 8 *deg.* 17 *min.* Thirdly, The Height of the Pole above the Plane is 14 *deg.* 1 *min.* Fourthly, The Difference of Longitude or Inclination of Meridians is 31 *deg.* 1 *min.* as you may ſee in *Chap.* 18. Theſe being found, you muſt thus proceed in the delineation of your Dial.

Firſt with your Compaſſes take from off your Scale a Chord of 60 *deg.* and on the Center C ſweep the Arch H L R P, and draw C H the Horizontal Line blindly. Then from H ſet off the ſeveral Diſtances before found, upon this Arch of a Circle, *viz.* Firſt, H L 54 *deg.* 44 *min.* for the Arch of the Plane between the Horizon and the Meridian. Then ſet off L R 8 *deg.* 17 *min.* for the Diſtance of the Subſtile from

the Meridian, and there draw the Line of the Substile C R B. Thirdly, From this Point R set off R P, which is 14 *deg.* 1 *min.* for the Height of the Stile above the Substile, and draw the prick'd Line C P K for the Stile or Axis.

Now this Stile being but somewhat low, for the enlarging hereof, first chuse some convenient place in your Substiles Line, as in this Example at B, and there draw the Line F B A squire wise to the Substiles Line. Then take with your Compasses from off your larger Polar Line marked ✠ the Distance of three Hours, and prick it down in this Line from B to I; then from this Point I take with your Compasses the neerest distance to the Line of the Stile, and with that distance draw the Line I L parallel to the Stile, and this will be the Line of the Stile inlarged.



Now to set on the lesser Polar Line, that so you may draw the Hour-lines, first take from off your lesser Polar Line marked ⊢, the distance of 3 Hours, and with that distance draw a little white Line parallel to the Line of the Stile, and note where it cuts the Line of the Stile inlarged, which is in the Point R. Mark this Point R well, and through this Point R draw the Line O G parallel to the former Polar Line F B A. And now if you take the distance E R in this Line, and measure it on your Scale, if you have done your work right, you shall find it just equal to 3 Hours upon the lesser Polar Line. And now by these two Polar Lines you must draw the Hour Lines after this manner.

First you must consider the Inclination of the Meridians, which in this Example is 31 *deg.* 1 *min.* which reduced into time, is 2 *ho.* 4 *min.* or 2 of the Clock and 4 *min.* in the afternoon, from whence you may frame a Table for your direction in placing the Hours, after this manner.

Now

Now according to this Table, take the distance of these Hour-lines first out of your larger Polar Line ☩, and prick them down in the Line F B A, from the Point B towards F and A. Thus the Line of II must be set 4 *min.* from the Substile B towards F; the Line of I must be set 1 *ho.* 4 *min.* from the Substile B toward F; the Line of XII must be set 2 *ho.* 4 *min.* from B towards F. And so on the other side of the Substile, the Line of III must be set 56 *min.* from the Point B toward A; the Line of IIII must be set 1 *ho.* 56 *min.* from B toward A. And so you must do till you have set down all the Hour-lines upon the Line F B A, taking them out of the larger Polar Line upon your Scale.

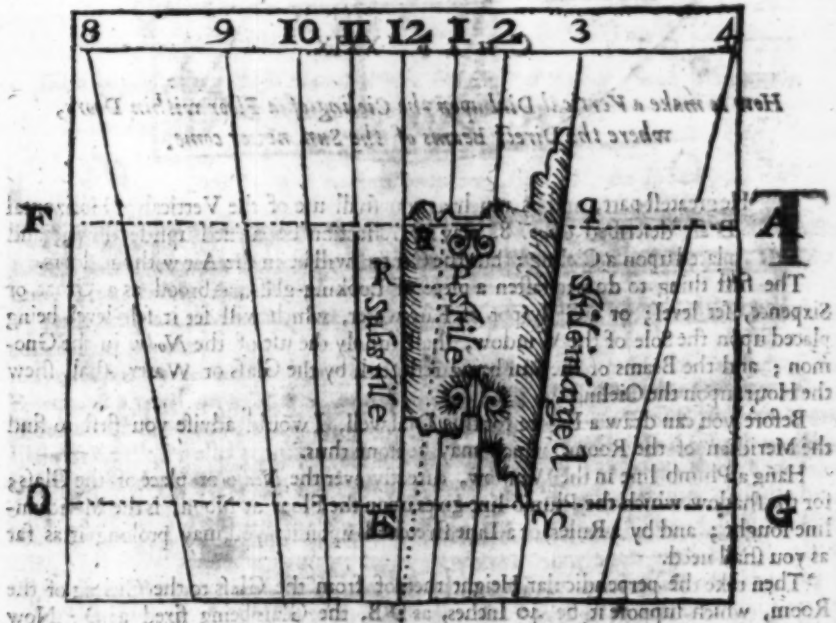
The Hour-lines of the Plane.	*Their dist. from the Substile.*		
	Ho.		*Mi.*
X	4	F	4
XI	3		4
XII	2		4
I	1		4
II	0		4
Substile	0	B	0
III	0		56
IIII	1		56
V	2		56
VI	3	A	56

Having thus set down the Hour-lines in the Line F B A, you must set them also in the Line O E G, taking their Distances off from your lesser Polar Line —, as before you did from the larger Polar Line, making use of the Table to direct you, as before.

And thus having made marks for the Hour-lines in both these Tangent-lines, you must draw the Hour-lines through these Marks; and so shaping your Dial into a Triangle, Square, or Circle, as your Plane will best allow, number the Hour-lines with their proper Figures, and so finish your Dial, as the Scheme will direct you better than many words.

CHAP. XXVIII.

Another Example, How to Inlarge the Stile in a South Dial, reclining 45 deg. *from the Zenith Northward.*



THE Stile or Gnomon in this Example is very low, lying very neer to the Pole of the World, as you may see before in the Fundamental Diagram. This Dial only reclines from the Zenith; and therefore to know the Stiles Height, you

you need only ſubſtract the Reclination from the Latitude of the Pole; which being 51 *deg.* 30 *min.* the Reclination 45 *deg.* ſubſtracted out of it, there remains 6 *deg.* 30 *min.* for the Height of the Stile.

This Dial hath no Declination, and therefore the Subſtile muſt be the Meridian-line; draw that Line therefore firſt about the middle of the Plane, and then with a Chord of 60 *deg.* deſcribe a ſhort Arch R P, and from R prick off 6 *deg.* 30 *min.* according to the Height of the Stile before-found, and thereby draw the prickt Line C P from the Center C, repreſenting the leſſer Stile of the Plane.

Now make choice of ſome fit place upon the Subſtiler Line, as B, and there croſs the Meridian at Right Angles with the Line F B A: Then take from off your larger Polar Scale ✣ the diſtance of 3 Hours, and prick it from B to q. Then take the neereſt diſtance from this Point q, to the Line of the Stile or Axis, and therewith draw a Line parallel to the Stile, and this ſhall be the Line of the Stile inlarged. Then take the diſtance of 3 Hours off from your leſſer Scale marked ⊢, and with that diſtance draw a blind Line parallel to the Meridian or Subſtile, and mark where it croſſeth the Line of the Stile Inlarged, which is in the Point ϒ: Then take the neereſt diſtance from this Point ϒ, to the former Polar Line F B A, and ſo draw the Line O E G parallel thereunto, through the Point ϒ: This ſhall be your leſſer Polar Line.

Now to ſet off the Hour-lines upon theſe two Lines, firſt take with your Compaſſes the diſtance of one Hour off from your ✣ Polar Scale, and prick it both ways from the Point B toward A and F: Likewiſe do the ſame for 2, 3, and 4 Hours, and prick them down in the Line F B A.

Then take the diſtances of each Hour alſo off from the leſſer Polar Scale ⊢, and prick them down from E on both ſides the Meridian Line, in the Line O E G. Then draw through theſe Points the Hour-lines by their ſeveral marks, as you may ſee in the Figure, and put the numbers of the Hours thereunto; ſo your Dial will be finiſhed, as in the Figure. And if you well underſtand this, you may do the like in any other Dial which ſhall need inlarging.

CHAP. XXIX.

How to make a Vertical Dial upon the Cieling of a Floor within Doors, where the Direct Beams of the Sun never come.

THe greateſt part, and as much as you ſhall uſe of the Vertical or Horizontal Dial, deſcribed *Chap.* 8. may by reflection be turned upſide down, and placed upon a Cieling; but the Center will be in the Air without doors.

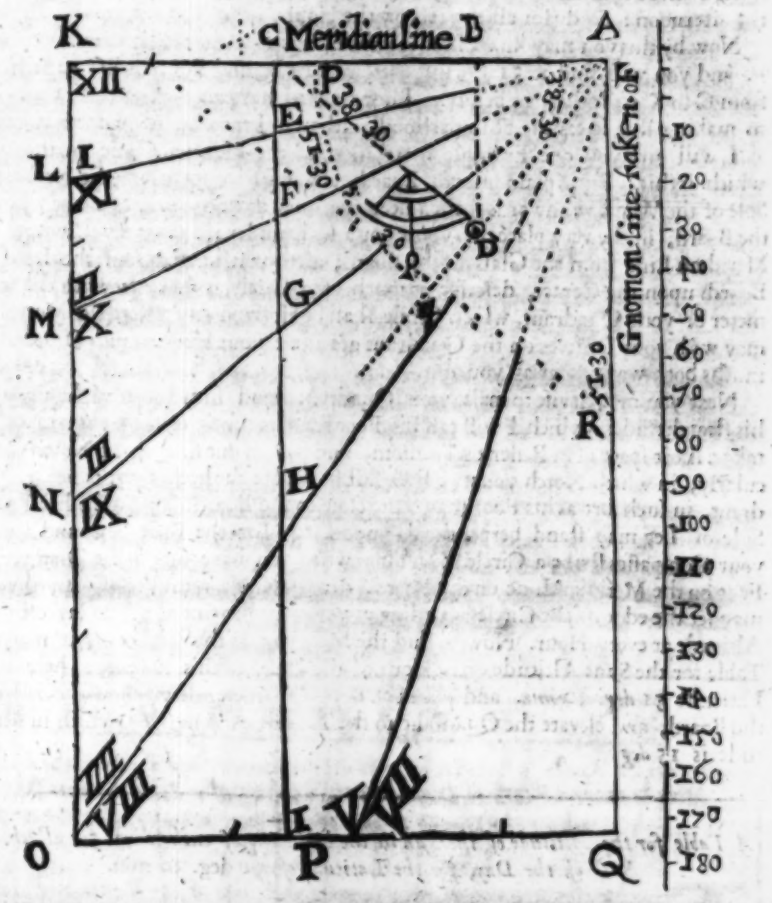
The firſt thing to do is to faſten a piece of Looking-glaſs, as brood as a Groat or Sixpence, ſet level; or a Gally-pot of Fair-water, which will ſet it ſelf level being placed upon the Sole of the Window, ſhall ſupply the uſe of the *Nodus* in the Gnomon; and the Beams of the Sun being reflected by the Glaſs or Water, ſhall ſhew the Hours upon the Cieling.

Before you can draw a Figure for this Dial well, I would adviſe you firſt to find the Meridian of the Room, which may be done thus.

Hang a Plumb line in the Window, directly over the *Nodus* or place of the Glaſs; for the ſhadow which the Plumb-line gives upon the Floor at Noon, is the Meridian-line ſought; and by a Ruler, or a Line ſtretched upon it, you may prolong it as far as you ſhall need.

Then take the perpendicular Height thereof from the Glaſs to the Cieling of the Room, which ſuppoſe it be 40 Inches, as D B, the Glaſs being fixed at D: Now from B draw the Meridian-line upon the Cieling, which ſhall be repreſented both ways continued, as A B C K, and from D erect a Perpendicular to D C: Or let a ſtander by ſtop one end of a Thred on the Glaſs at D; extend the ſame to the Meridian-line, moving the end of the ſtring ſhorter and longer upon the Meridian, till

another holding the Side of a Quadrant, ſhall find the Thred and Plummet to fall directly upon the Complement of the Latitude, which in this Example is 38 *deg.* 30 *min.* and that is the Interſection of the Æquinoctial. Then raiſe the Perpendicular, as D A; take a Chord of 60 *deg.* and from A ſweep the Arch at P, and from P lay down the Latitude 51 *deg.* 30 *min.* to q, and draw the Line A D.



Then let fall a Perpendicular from C, as C E F G H I, which is the Æquinoctial Line; and ſo likewiſe draw a Parallel Line to the Meridian of 40 Inches at D. Now note, That the Hours muſt be drawn all one as the Horizontal Dials are.

Then draw a Line Parallel to the Æquinoctial, as K O, at what diſtance you think convenient, on the Cieling of the Room, which let be here 50 Inches, as C K, as you may meaſure by the Scale. Now for the placing of the Hours on the Cieling of the Room, you muſt meaſure how much by the Scale of Inches each Diſtance on the Æquinoctial Line is from C to E, and from C to F, and from C to G, H, and I, and likewiſe on the Parallel from K, collecting them into a Table; ſo will it be ready to tranſport on the Cieling.

Here I have made the Table.

	Inches. par.			*Inches. par.*	
C E	17	0	K L	27	7
C F	38	0	K M	59	7
C G	63	3	K N	101	0
C H	111	4	K O	173	0
C I	222	5	K P	385	8

So

So by this Table you ſhall find the Diſtance C E, which is from 12 to 1 in the afternoon, or 11 in the morning, to be 17 Inches; which you may prick upon the Cieling. Likewiſe K L on the Parallel, between 12, 11, and 1, will be found to be 27 Inches $\frac{7}{10}$ parts of an Inch in 10 parts; which Hour-line mark out upon the Cieling. Then draw a ſtraight Line through thoſe two Points L and E; this Line continued ſhall be the firſt Hour from the Meridian, which is 11 in the morning, or 1 in the afternoon: So do for all the reſt of the Hours.

Now by this you may know how far the Center is without the Window; meaſure it, and you will find it 31 $\frac{52}{100}$ Inches from A to B, and from B to C 52 Inches, and from C to K 50 Inches, as before. I hope now I have given the Practicioner content, in making this ſo eaſie to be underſtood, although I may be condemned by others.

I will give you one Example more, to find the Meridian Line on the Cieling, which is this. Fit a plain ſmooth Board, about a Foot ſquare, to lie level from the Sole of the Window inwards; then neer the outward edge thereof make a Center in the Board, in the very place of *Nodus*, or a little under it: Then by *Chap.* 3. get the Meridian Line from the Glaſs on the Board; after you have drawn the Line on the Board upon the Center, deſcribe as much of a Circle as you may with the Semidiameter of your Quadrant, which Circle ſhall be Horizon; then from the Meridian you may with your Degrees on the Quadrant graduate your Horizon into Degrees of Azimuths both ways as far as you can.

Next you may deviſe to make your Quadrant ſtand firm and upright upon one of his ſtraight Sides, which I will call his Foot for this time; and that you may thus do, take a ſhort ſpace of a Ruler or Tranſom, and ſaw in one ſide of it a Notch perpendicularly, in which Notch you may ſtick faſt or wedge the heel of the toe of your Quadrant, in ſuch ſort as his Foot may come cloſe to the Board, and the other Triangular Side or Leg may ſtand perpendicular upon it. Let the Foot be round, and with your Compaſſes ſtrike a Circle round it: when you have fitted the Diameter of the Foot on the Meridian Line on the Board, draw a Circle round the Glaſs, that ſo you may ſet the edge of the Circle according as you may have need, for to lay off the Suns Altitude at every Hour. Now to find the Meridian on the Cieling, you may make a Table for the Suns Altitude every Hour of the Day, in this manner as here is for the Latitude 51 *deg.* 30 *min.* and place the Foots Diameter directly on the Meridian of the Board, and elevate the Quadrant to the Tropick of *Capricorn*, which in this Latitude is 15 *deg.*

A Table for the Altitude of the Sun in the beginning of each Sine, for all the Hours of the Day, for the Latitude of 51 deg. 30 min.

Hours.	*Cancer.*	*Gemini. Leo.*	*Taurus. Virgo.*	*Aries. Libra.*	*Piſces. Scorpio.*	*Aquari. Sagitta.*	*Capric.*
12	62 0	58 45	50 0	38 30	27 0	18 18	15 0
11 1	59 43	56 34	48 12	36 58	25 40	17 6	13 52
10 2	53 45	50 55	43 12	32 37	21 58	13 38	10 30
9 3	45 42	43 6	36 0	26 7	15 58	8 12	5 15
8 4	36 41	34 13	27 31	18 8	8 33	1 15	
7 5	27 17	24 56	18 18	9 17	0 6		
6 6	18 11	15 40	9 0				
5 7	9 32	6 50					11 37
4 8	1 32						21 40

Let a ſtander by ſtop on the Glaſs a Thred, and extend the other part ſtraight on to the Cieling, the Thred touching only the Plane of the Quadrant, and making no Angle with it, but held parallel; and where the Thred thus extended touches the Cieling, make a Point; then the Quadrant unmov'd, elevated to 62 *deg.* of Altitude, and extend the Line, and make another Point as before; and between thoſe two Points draw a ſtraight Line, and that ſhall be your Meridian, and ſhall be long enough

enough for your uſe. Then elevate the Quadrant to 38 *deg.* 30 *min.* and hold the Thred to the Meridian on the Cieling, and where he touches mark; and croſs the Meridian at Right Angles with an Infinite Line, which ſhall be the Æquator: So you may do as you did before. but if the Plane of the Cieling of the Wall is interrupted, and made irregular by Beams, Wall-places, Corniſhes, Wainſcot, or Chimney-piece, and ſuch like Bodies, I will ſhew you the Remedy to carry on your Hour-lines over all.

Extend the Thred from any Hour-line to the Tropick of *Cancer* in the Cieling, as you were taught before, and fix it there; and extend another Thred in like manner to the Tropick of *Capricorn*, where-ever it ſhall happen beyond the middle Beam, or quite beyond the Cieling upon the Wall, and fix the Threds alſo. Then place your eye ſo behind theſe Threds, that one of them may cover another; and at the ſame inſtant where the upper Line to your ſight or Imagination cuts the Cieling, Beam, Wall, or any irregular Body, about the end of the lower Line, there ſhall the Hour-line paſs from Tropick to Tropick: Direct any By-ſtander to make Marks, as many as you ſhall need, and by thoſe Marks draw the Hour-lines according to your deſire. This is in Mr. *Palmer*, *pag.* 202.

If the Arch of the Horizon, between the Tropicks, be within view of your Window, you ſhall draw the ſame on the Wall to bound the Parallels. The Horizon Altitude is nothing, and therefore it will be a level Line: and the Suns Azimuth when he riſeth, commonly called Ortine Latitude, is in *Cancer* 40 *deg.* Eaſt Northward, and in *Capricorn* as much Southward; and theſe will be reflected to the contrary Coaſts on the Dial.

CHAP. XXX.

How to make an Univerſal Dial on a Globe; and to cover it, if it be required.

A *Globe*, ſaith *Euclid*, *is made by the turning about of a Semicircle, keeping the Diameter fixed.* This Dial, if Univerſal, will want the aid of a Magnetical Needle to ſet it, and it muſt move on an *Axis* in an Horizon, as the uſual Globes do; whoſe Æquator let be divided into 24 Hours, the proportion of the Day Natural.

You may ſee the Figure on the top of the Dial in the Title, but that you cannot ſee the two Poles, and the Semicircle, and the Horizontal Circle.

You may imagine this Globe ſet to the Elevation of the Pole, as that is, with two Gnomons of the length of the Suns greateſt Declination, proportioned to the Poles Circle, with the 24 Hours, according to the 24 Meridians, and ſerves for a North and South Polar Dial.

But in the Meridian let be placed the 12 a Clock Line; then turn the Semicircle till it caſt no ſhadow: then doth it croſs the Hours, which Hours are drawn from the Pole to each of the 24 Diviſions, as before.

If you deſire to cover the Globe, and make other Inventions thereon, firſt learn here to cover it exactly. With a Pair of Compaſſes bowed towards the Points (like a Pair of Calapers the Gunners uſe) meaſure the Diameter of the Globe you intend to cover; which being known, find the Circumference thus.

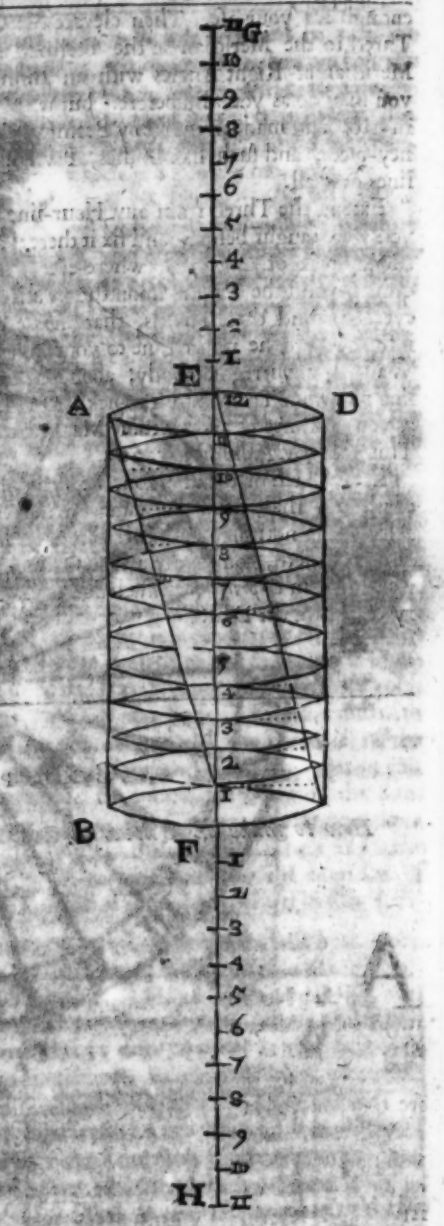
Multiply the Diameter by 22, and divide the Product by 7, and you have your deſire.

Let the Circumference found be the Line E F, which divide into 12 Equal parts; draw the Parallel A B and C D, at the diſtance of three of thoſe Parts from E to A and from F to C; then by the outward Bulks of thoſe Arches draw the Line A B and C D.

And to divide the Circumference into 12 parts, as our Example is, work thus.

Set your Compasses in E, and make the Arch F C: The Compasses so opened set again in F, and make Arch E A; then draw the Line from A to F, and from E to C. Then your Compasses opened at any distance, prick down one part less on both those slanting Lines, than you intend to divide thereon; which is here 11, because we would divide the Line E F into 12: Then draw Lines from each Division to his opposite, that cuts the Line E F in the parts of Division. ——But to proceed, It is Mr. *Morgan*'s Conceit, *page* 116. Continue the Circumference at length to G and H, numbring from E towards G 12 of those Equal Parts, and from F towards H as many, which shall be the Center for each Arch; so those Quarters so cut out, shall exactly cover the Globe, whose Circumference is equal to E F.

Thus have you a glance of the Mathematicks, striking at one thing through the side of another: For here one Figure is made for several Operations, to save the Press the charge of Figures.

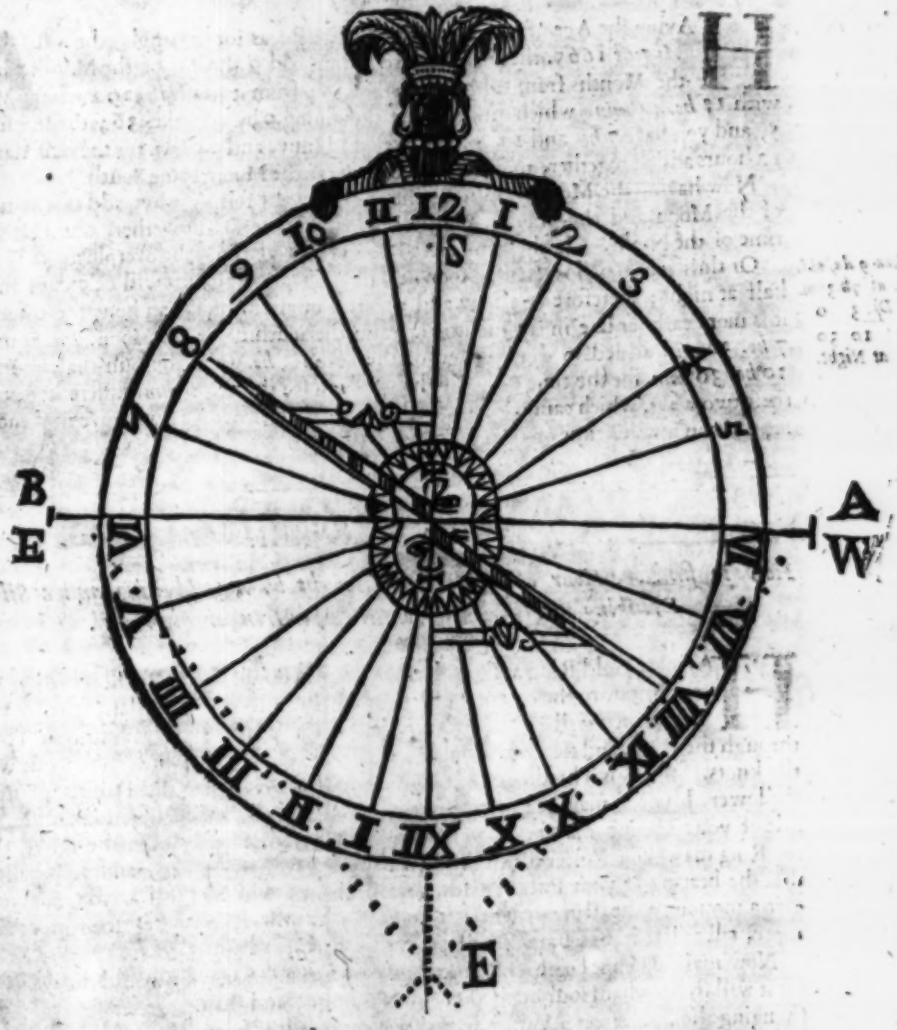


CHAP. XXXI.

How to make a Direct North Dial for the Cape of Good Hope, ***in South Latitude*** 35 d. ***and Longitude*** 57 d. ***to the Eastward of*** Flores ***and*** Corvo.

THis Dial is made all one as the South Dial you may see *Chap.* 9. Only observe this, That you are 35 *deg.* to the Southward of the Æquinoctial, and that the Sun, when he is on the Tropick of *Capricorn*, wants 11 ½ Degrees of the Zenith of that Place Northward: As the Sun goes always to the Southward of us in *England*, so it goes to the Northward of them; therefore must the Stile or Gnomon point downward in the North Face, and upward in the South Face. So likewise as in our South Dial the afternoon Hours are put on the East side the Dial Plane, and the

the morning Hours on the Weſt ſide; ſo in their North Dials they will ſtand contrarily, by reaſon the Sun caſts a Shadow (as the Plane muſt ſtand there) in the morning to the Weſt ſide, and in the afternoon to the Eaſt: So you ſee the Plane is only turned to face the Sun. If you do but conceive in your mind how the Sun



caſts his ſhadow, you may as eaſily make all ſorts of Dials on the South ſide of the Æquinoctial, as on the North ſide: but that the People there have neither Order, Policy, Religion, nor Underſtanding in Mathematical Arts or Sciences. The *Africans* at the *Cape of Good Hope* are of a ſwarthy dark colour, and made black by daubing themſelves with Greaſe and Charcoal; they are ſo wedded to ſuperſtition, that ſome adore the Devil in the form of a bloody Dragon, others a Ram, a Goat, a Leopard, a Bat, an Owl, a Snake, or Dog, to whom they ceremoniouſly kneel and bow. So much for *Æthiopia*, and for Dials for them; only you ſee the manner, and that the former Rules ſerve for any Latitude.

CHAP. XXXII.

How to find the Time of the Night by the Moon ſhining upon a Sun Dial.

HAving the Age of the Moon by the Epact: as for Example, the 9th. day of *Auguſt* 1665. the Epact is 3, to which add 9 the day of the Month, and 6 the Months from *March*, makes 38; from it ſubſtract 29 a whole Moon, with 12 *ho.* 44 *min.* which multiply the remaining 9 by 4, makes 36; that divide by 5, and you have 7 *ho.* and 12 *min.* for the odd Unite, and 24 *min.* for the half day, or 12 hours added together, makes 7 *ho.* 36 *min.* for the Moon being South.

Now having the Moons coming to the South by the former way, add this Southing of the Moon and the Shadow of the Moon upon the Dial together, and that is the time of the Night. If the Sum exceed 12 Hours, take only the overplus.

Moon 9 da. old. So. at 7h. 30m. ☉ *Di.* 3 0 — 10 30 *at Night.*

Or thus you may do: If the Moon be 9 days old at Noon, ſhe will be 9 days and an half at night; therefore you may add about a quarter or half an hour thereunto, as it is more early or late in the night, and add the Southing of the Moon, which makes 7 *ho.* 30 *min.* added to the Shadow of the Moon 3 *ho.* upon the Sun-dial, it makes 10 *ho.* 30 *min.* for the time of the night: So you ſee there is 6 *min.* difference betwixt theſe two ways, which cannot well be eſtimated; but either way will give neer enough ſatisfaction for the time of the Night.



CHAP. XXXIII.

How to find the Hour of the Day or Night by a Gold Ring and a Silver Drinking Bowl, or Glaſs, or Braſs, or Iron, or Tin Veſſel.

HAving a Gold Ring and a Silver Drinking Bowl, take a ſmall Thred or Silk and meaſure the compaſs of the top of the Silver Bowl, Glaſs, or other Veſſel, which will be a convenient length for your uſe: Then put this Thred through the Ring, and tie the ends thereof together, taking up as little as you can with the knots. Put this Thred over your Thumb, where you feel the Pulſe beat, upon the lower Joynt it may be; then ſtretch out your Hand, and hold it ſo that the inſide of your Thumb may be upward; and hold your Hand ſo over the Bowl, that the Ring may hang as neer the midſt of the Bowl as you can gueſs: and you ſhall ſee that the beating of your Pulſe (holding your Hand a while as ſtill as you can) will give a motion to the Ring, cauſing it to ſwing croſs the Bowl by Degrees more and more, till at laſt it will beat againſt the Sides thereof.

Now mark when it begins to ſtrike, and tell the ſtrokes as you would do a Clock; for it will ſtrike what Hour of the Day or Night it is, and then leave off ſtriking, and ſwinging alſo by degrees: Which hath been approved of by the experience and judgment of many.

A Good Obſervation.

WE may take notice, That there is no Dial can ſhew the exact time, without the allowance of the Suns Semidiameter, which in a ſtrict acceptation is true. But hereto Mr. *Wells* hath anſwered in *page* 85. of his *Art of Shadows*, where ſaith he, *Becauſe the Shadow of the Center is hindered by the Stile, the Shadow of the Hour-line proceeds from the Limb, which always precedeth the Center one minute of time, anſwerable to* 15 *minutes the Semidiameter of the Sun: which to allow in the Height of the Stile were erroneous; but there may be allowance in the Hour-line, detracting from the true Æquinoctial Diſtance of every Hour or* 15 *degrees,* 15 *minutes.* But I will go no further with this Subject, to put the Learners in doubt of the true Hour; for this is as neer a way which I have ſhewed you, as any projected upon Dial Planes. You may ſee a Geometrical Figure of it in my Problems of the Sphere.

CHAP.

CHAP. XXXIV.

How to Paint the Dials which you make.

ALthough I never ſaw any man Make a Dial, nor paint one, but what I made, painted, and guilded my ſelf; as you may ſee the Piece in the Title, on which I made 26 Dials, and put in the Braſs Gnomons or Stiles into the Freeſtone with Lead, and guilded them with all the Figures, and on the Globe drew the Æquinoctial Circle, the Ecliptick, the Tropicks, and Polar Circles, and the 24 Meridians, with ſuch Conſtellations in the North and South Hemiſphere, and Stars, in ſuch Colours as was fit to ſet out the Dial, with Pole Dials, and Globe Dials, *Chap.* 32.

To Paint and Finiſh the Dials, ready to be ſet up in their Places.

FOr to faſten the Gnomon to the Plane, be it of Wood or Freeſtone, you muſt have a ſmall thin Chiſel, or Googe, or Gimblet, as is fit for the Stile, be it round as a Rod of Iron, or a piece of Braſs, let in with a Foot an inch and half, or more or leſs, as you will; and in the Wood make ſuch little Mortiſes as juſt the breadth and length of the Foot of the Stile; and if it comes thorow to clinch it on the other ſide, then it is faſt.

If it is in Freeſtone, your Dial drawn firſt in Paper, lay it upon the Plane as it ſhould be; then cut out the Subſtile-line as neer its breadth as you can, and only leave ſo much as will juſt hold it together. The Paper laid as before on the Plane, with a Black-lead Penſil, or ſuch like, draw the Subſtile Line where it ſtood in the Paper, and with a ſmall Chiſel make ſuch Mortiſes in that Line as are anſwerable to the Foot of the Stile; and crook his Foot, and put it into its place, with a ſmall Ladle and ſome Lead melted, put the Stile perpendicular with the Plane, and pour in the Lead into the Mortiſe until it is full; and when it is cold, then with a blunt Chiſel harden the Lead in one Inch ſide of the Stile or Gnomon: And if the Mortiſe ſhould be too wide, or broken, and not even enough with the Plane, then wet ſome Flower of Alabaſter, as you may have it fit for that purpoſe at any Maſons, and as ſoon as 'tis wet make a Plaſter, and ſo ſmooth it, and ſpread it even and plain with the Plane; it is preſently dry. Now have you the Stile or Gnomon as faſt as if it grew there.

To Paint them, you muſt firſt Prime them: The Prime is made thus. Take an equal quantity of Bole Armoniack and Red Lead, well ground together with Linſeed Oyl, and well rubb'd in with a Bruſh or Penſil into the Plane; that being dry, for the outſide Colour, it is White Lead or Ceruſe well ground together with Linſeed Oyl. How to know the beſt. Buy the White Lead, and grind it to a Powder, and put it into Water until it become as thick as Pap, and let it dry; then it is for your uſe.

For the Hour Lines a Vermillion, and a part Red Lead, well ground together with Linſeed Oyl, with a ſmall quantity of Oyl of Spike, or Turpentine that will dure, and make the Lines ſhine.

For a Gold Border, Rub the Border well with the white Ceruſe Paint; be ſure it be very thick in the Border: Then with Blew Smalts ſtrew very thick the Border while it is wet; and when it is dry, wing that which is looſe off, and ſave it in a Paper; and for the reſt that clings, it is faſt enough.

Take Red Lead and White Lead, and as much Red Lead again as White, or Yellow Oker, well ground with Oyle of Spike or Turpentine; this is the Size: Then draw with that the Figure you would have in Gold, and when it is ſo dry that it will not come off on your Fingers by a ſlight touch, lay on the Gold; and when it is thorowly dry, wing it off.

How to make a good Black, to ſhadow or make Figures. Grind well with Linſeed Oyl Lam-black, with ſome Verdigreaſe, and that is a firm Black. The like you may do with all other Colours, as you fancy for ſuch Work.

A Receipt for Red Ink.

FIrſt, Steep one penny-worth of Brazeel Wood all night in Piſs or Urin; then boil it well and ſtrain it; then bruiſe two penny-worth of Cochineel, and boil it, and put in it the bigneſs of a Hens Egg of Roch Allom, that brings it to a colour, and then it is for your turn:

To Paint Freeſtone, waſh the Stone with Oil, and it will laſt; and then all the Colours before may be uſed, as directed.

How to cleanſe a Picture.

TAke blew Smalts, temper it in Water, and rub the Picture with it, and after wipe it with a Linnen Cloth, which Cloth ſhould be dipp'd in Beer, or otherwiſe with a dry Cloth, and it is clean.

To cleanſe a Gold Border.

WAſh it with Beer, and dry it, and then cleanſe it with Linſeed Oyl.

Maſticous is a fine Yellow, ground with ſome Oyl of Spike or Turpentine.

Bice is a good Blew Colouring, to be ground with Linſeed Oyl and Red Lead.

And *Spaniſh* Brown will make a laſting Colour for Courſe Work.

To grind Gold to Write and Paint.

TAke as many Leaves of Gold as you pleaſe, Honey three or four drops; mix and grind theſe, and keep it in ſome Bone Veſſel. If you will write with it, add ſome Gum-water, and it will be Excellent.

Some Uſes of the following Tables of Logarithmes, Sines, *and* Tangents.

AMongſt the many admirable ways that have been from time to time invented for propagating the Arts Mathematical, and eſpecially that of *Trigonometry*, *Logarithmes*, invented by the Right Honourable the Lord *Napier*, Baron of *Marcheſton*, may challenge the priority, and the Tables of *Artificial Sines* and *Tangents*, compoſed by Mr. *Edmund Gunter* Profeſſor of Aſtronomy in *Greſham-College London*; for that they expedite the Arithmetical Work in moſt Queſtions; Multiplication being performed by Addition, and Diviſion by Subſtraction, the Square Root extracted by Bipartition, and the Cubique Root by Tripartition: So that by help of theſe Numbers, and the aforeſaid *Sines* and *Tangents*, more may be performed in the ſpace of an Hour, than by Natural Numbers or by Vulgar Arithmetick can be in ſix. Now of what frequent uſe the Doctrine of Triangles, both Plain and Spherical, is in Aſtronomy (for the Reſolution of which the Tables following chiefly ſerve) let the precedent Work teſtifie. And as Mr. *Newton* in his *Mathematical Inſtitutions*, or in the ſame form as Mr. *Vincent Wing* in his *Harmonicon Cœleſte*, are theſe Tables following: And therefore I think it not amiſs here in this place to inſert ſome few Propoſitions, to ſhew the Uſe of the *Canon* and Tables of *Sines* and *Tangents* following.

PROBL. I.

How to find the Logarithmes of any Number under 1000.

EVery Page in the Table of *Logarithmes* is divided into 11 Columns; the firſt of which Columns, having the Letter N at the Head thereof, are all Numbers ſucceſſively continued from 1 to 1000: So that to find the *Logarithmes* of any Number,

ber, is no more but to find the Number in the first Column, and in the second Column you shall have the *Logerithme* answering thereunto.

Example. Let the Number given be 415, and if it is required to find the *Logarithme* thereof, in the Table of *Logorithmes*, in the first Column thereof, under the Letter N, I find the Number 415, and right against it in the next Column I find 618048, which is the *Logarithme* of 415. In the same manner you may find the *Logarithme* under 1000; as the *Logarithme* of 506 is 704151, and the *Logarithme* of 900 is 954243, *&c.*

But here is to be noted, That before every *Logarithme* must be placed his proper Characteristick; *viz.* If the Number consist but of one Figure, as all Numbers under 10, then the Characteristick is 0; if the Number consist of two Figures, as all Numbers between 10 and 100, then the Characteristick is 1; if the Number consist of three Figures, as all Numbers betwixt 100 and 1000, then the Characteristick is 2; and if the Number consist of four Figures, as all between 1000 and 10000, the Characteristick must be 3. In brief, the Characteristick of any *Logarithme* must consist of an Unit less than the given Number consisteth of Digits or Places: And by observing this Rule, the *Logarithme* of 415 will be 2.618048, and the *Logarithme* of 506 is 2.704151, and the *Logarithme* of 900 is 2.954243, *&c.*

PROBL. II.

A Logarithme being given, to find the Absolute Number thereunto belonging, by the former Observation; the Characteristick will declare of what Number of Places the Absolute Number consisteth.

Example. Let the *Logarithme* given be 2.164353; now because the Characteristick is 2, I know by it the Absolute Number consisteth of three places, and therefore may be found in the second Column of the *Logarithme* Tables, having 0 at the top thereof, against which I find 146, which is the Absolute Number answering to the *Logarithme* of 2.164353.

PROBL. III.

How to find the Logarithme of a Number that consisteth of four Places.

You must find the three first Figures of the given Number in the first Column, as before, and seek the last Figure thereof amongst the great Figures in the head of the Page; and in the common Area or meeting of these two Lines is the *Logarithme* you desire, if before it you add or prefix its proper Characteristick.

Example. Let it be required to find the *Logarithme* of 57453 I find 574, the three first Figures, in the first Column, and 5, the last Figure, in the head of the Table; then going down from 5 in the head of the Table, until I come against 574 in the first Column, there I find 759290, before which I place 3 for the Characteristick, which is 3.759290, and that is the *Logarithme* sought for.

PROBL. IV.

Any Number of Degrees and Minutes being given, to find the Artificial Sine and Tangent thereof.

Admit it were required to find the Sine of 21 *deg.* 24 *min.* I turn to the Sines in the Table, and in the head thereof I find Degrees 21; then in the first Column (under M) I find 24, and right against it is 9.562146 for the Sine, and 9.593170 for the Tangent of 21 *deg.* 24 *min.* But suppose it were required to find the Sine or Tangent of 56 *deg.* 35 *min.* look for all else under 45 *deg.* are found in the head, and the odd *min.* in the left hand; and all above 45 *deg.* are found in the foot of the Table, and the *min.* in the last Column toward the right hand; as in this Example the Sine of 56 *deg.* 35 *min.* is 9 921524, and the Tangent is 16.180590.

PROBL.

PROBL. V.

If any Sine or Tangent be given, to find what Degrees and Minutes anſwer thereunto.

Suppoſe 9.584663 were a Sine given, I look for the Number in the Table of Sines, and I find it ſtand againſt 22 *d.* 36 *m.* and therefore is the Sine thereof. As admit 9.624330 were a Tangent given, look for the Number in the Column of Tangents, and I find ſtand againſt it 22 *d.* 50 *m.* The ſame muſt be done for Sines and Tangents in the foot of the Tables.

Ovid. lib. Met.

Cuncta fluunt omniſque vagans formatur Imago.
Ipſa quoque aſſiduo labuntur tempora motu.

All things paſs on: Thoſe Creatures which are made
Fail, and by Time's aſſiduate motion fade.
Much like the Running Stream, which cannot ſtay,
No more can the light Hours that poſte away.
But as one Billow, haſt'ning to the Shore,
Impels another, and ſtill that before
Is by the following driv'n; ſo we conclude
Of Time, it ſo flies, and is ſo purſu'd.
The Hours are always new; and what hath been
Is never more to be perceiv'd or ſeen:
That daily grows, which had before no ground;
And Minutes, paſt once, never more are found.

Lib. Eleg. 2.

Labitur occulte fallitque volubilis ætas.

The fretting Age deceives, and ſtealing glides;
And the ſwift Year on looſe-rein'd Horſes rides.

Quid non longa dies? quid non conſumitis Anni?

The End of the Seventh Book.

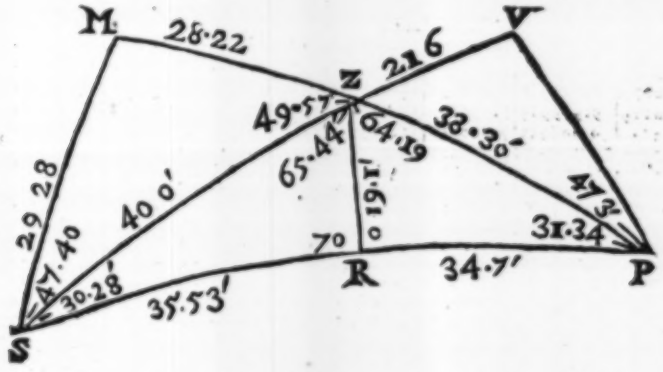
CANON
TRIANGULORUM
LOGARITHMICUS.

OR,

A TABLE of ARTIFICIAL SINES and TANGENTS to every Degree and Minute of the *QUADRANT.*

The Common Radius being 10,000000.

By Capt. SAMUEL STURMY.



The Description of the TRIANGLE.

Let Z P S *repreſent the* Zenith, Pole, *and* Sun, Z P *being* 38 deg. 30 min. *Complement of the Latitude,* P S *the Complement of the Suns Declination* 70 deg. *and the Complement of the Suns Altitude* Z S 40 deg. 00 min. *the Angle at* Z *ſhall ſhew the Azimuth, and the Angle at* P *the Hour of the Day from the Meridian: Then if from* Z *to* P S *we let down a Perpendicular, as* Z R, *we ſhall reduce the Oblique Triangle into two Rectangled Triangles* Z R P *and* Z R S: *If from* S *to* Z P *we let down a Perpendicular* S M, *we ſhall reduce the ſame* Z P S *into two other Triangles, as* S M Z *and* S M P *Rectangled at* M. *Whatſoever is ſaid of any of theſe Triangles, the ſame holdeth for all other Triangles in the like Caſes.*

London, Printed by *E. Cotes, Anno Dom.* 1669.

1290 : 89

Canon Triangulorum Logarithmicus.

Degree 0.

M	Sine	Co-sine	Tangent	Co-tang.
	0.000000	10.000000	0.000000	Infinita.
1	6.463726	9.999999	6.463726	13.536274
2	6.764756	9.999999	6.764756	13.235244
3	6.940847	9.999999	6.940847	13.059153
4	7.065786	9.999999	7.065786	12.934214
5	7.162696	9.999999	7.162696	12.837304
6	7.241877	9.999999	7.241878	12.758122
7	7.308824	9.999999	7.308825	12.691175
8	7.366816	9.999999	7.366817	12.633183
9	7.417968	9.999999	7.417970	12.582030
10	7.463726	9.999998	7.463727	12.536273
11	7.505118	9.999998	7.505120	12.494880
12	7.542906	9.999997	7.542908	12.457091
13	7.577668	9.999997	7.577672	12.422328
14	7.609853	9.999996	7.609857	12.390143
15	7.639816	9.999996	7.639820	12.360180
16	7.667844	9.999995	7.667849	12.332151
17	7.694173	9.999995	7.694179	12.305821
18	7.718977	9.999994	7.719003	12.281997
19	7.742477	9.999993	7.742484	12.257516
20	7.764754	9.999993	7.764761	12.235239
21	7.785943	9.999992	7.785951	12.214049
22	7.806146	9.999991	7.806145	12.193845
23	7.825451	9.999990	7.825460	12.174540
24	7.843934	9.999989	7.843944	12.156056
25	7.861662	9.999988	7.861674	12.138326
26	7.878695	9.999988	7.878708	12.121292
27	7.895085	9.999987	7.895099	12.104901
28	7.910879	9.999986	7.910894	12.089106
29	7.926119	9.999985	7.926134	12.073866
30	7.940842	9.999983	7.940858	12.059142
31	7.955082	9.999982	7.955100	12.044900
32	7.968870	9.999981	7.968889	12.031111
33	7.982233	9.999980	7.982253	12.017747
34	7.995198	9.999978	7.995215	12.004781
35	8.007787	9.999978	8.007810	11.992191
36	8.020021	9.999976	8.020044	11.979956
37	8.031919	9.999975	8.031945	11.968055
38	8.043501	9.999973	8.043527	11.956473
39	8.054781	9.999972	8.054809	11.945181
40	8.065776	9.999971	8.065806	11.934194
41	8.076500	9.999969	8.076531	11.923469
42	8.086965	9.999968	8.086997	11.913003
43	8.097183	9.999966	8.097217	11.902783
44	8.107167	9.999964	8.107203	11.892797
45	8.116926	9.999963	8.116963	11.883037
46	8.126471	9.999961	8.126510	11.873490
47	8.135810	9.999959	8.135851	11.864149
48	8.144953	9.999958	8.144996	11.855004
49	8.153907	9.999956	8.153952	11.846048
50	8.162681	9.999954	8.162737	11.837273
51	8.171280	9.999952	8.171328	11.828672
52	8.179713	9.999950	8.179763	11.820237
53	8.187985	9.999948	8.188036	11.811964
54	8.196101	9.999946	8.196156	11.803844
55	8.204070	9.999944	8.204126	11.795874
56	8.211895	9.999942	8.211953	11.788047
57	8.219581	9.999940	8.219641	11.780359
58	8.227134	9.999938	8.227195	11.772805
59	8.234557	9.999936	8.234621	11.765379
60	8.241855	9.999934	8.241921	11.758079
M	Co-sine	Sine	Co-tang	Tangent

Degree 89.

Degree 1.

Sine	Co-sine	Tangent	Co-tang.	M
8.241855	9.999934	8.241921	11.758079	60
8.249033	9.999932	8.249102	11.750898	59
8.256094	9.999929	8.256165	11.743835	58
8.263042	9.999927	8.263115	11.736885	57
8.269881	9.999925	8.269956	11.730044	56
8.276614	9.999922	8.276691	11.723309	55
8.283243	9.999920	8.283323	11.716677	54
8.289773	9.999918	8.289856	11.710144	53
8.296207	9.999915	8.296292	11.703708	52
8.302546	9.999913	8.302634	11.697366	51
8.308794	9.999910	8.308884	11.691116	50
8.314954	9.999907	8.315046	11.684954	49
8.321027	9.999905	8.321122	11.678878	48
8.327016	9.999902	8.327114	11.672886	47
8.332924	9.999899	8.333025	11.666975	46
8.338753	9.999897	8.338856	11.661144	45
8.344504	9.999894	8.344610	11.655390	44
8.350180	9.999891	8.350289	11.649711	43
8.355783	9.999888	8.355895	11.644105	42
8.361315	9.999885	8.361430	11.638570	41
8.366777	9.999882	8.366889	11.633105	40
8.372171	9.999879	8.372292	11.627708	39
8.377499	9.999876	8.377621	11.622378	38
8.382762	9.999873	8.382889	11.617111	37
8.387962	9.999870	8.388092	11.611908	36
8.393101	9.999867	8.393234	11.606766	35
8.398179	9.999864	8.398315	11.601685	34
8.403199	9.999861	8.403338	11.596662	33
8.408161	9.999858	8.408304	11.591696	32
8.413068	9.999854	8.413213	11.586787	31
8.417919	9.999851	8.418068	11.581932	30
8.422717	9.999848	8.422869	11.577131	29
8.427462	9.999844	8.427618	11.572382	28
8.432156	9.999841	8.432315	11.567685	27
8.436800	9.999838	8.436962	11.563038	26
8.441394	9.999834	8.441560	11.558440	25
8.445944	9.999831	8.446110	11.553990	24
8.450440	9.999827	8.450613	11.549387	23
8.454893	9.999824	8.455070	11.544930	22
8.459301	9.999820	8.459481	11.540519	21
8.463665	9.999816	8.463849	11.536151	20
8.467985	9.999812	8.468172	11.531828	19
8.472263	9.999809	8.472454	11.527546	18
8.476498	9.999805	8.476693	11.523307	17
8.480693	9.999801	8.480892	11.519108	16
8.484848	9.999797	8.485050	11.514950	15
8.488963	9.999794	8.489170	11.510830	14
8.493040	9.999790	8.493250	11.506750	13
8.497078	9.999786	8.497293	11.502707	12
8.501080	9.999782	8.501298	11.498702	11
8.505045	9.999778	8.505267	11.494733	10
8.508974	9.999774	8.509200	11.490800	9
8.512867	9.999769	8.513098	11.486902	8
8.516726	9.999765	8.516961	11.483039	7
8.520551	9.999761	8.520790	11.479210	6
8.524343	9.999756	8.524586	11.475414	5
8.528102	9.999753	8.528349	11.471651	4
8.531828	9.999748	8.532080	11.467920	3
8.535523	9.999744	8.535779	11.464221	2
8.539186	9.999740	8.539447	11.460553	1
8.542819	9.999735	8.543084	11.456916	0
Co-sine	Sine	Co-tang.	Tangent.	M

Degree 88.

Canon Triangulorum Logarithmicus.

Degree 2.					Degree 3.				
M	Sine	*Co-sine*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co tang.*	M
0	8.542819	9.999735	8.543084	11.456916	8.718800	9.999404	8.719396	11.280604	60
1	8.546422	9.999731	8.546691	11.453309	8.721204	9.999398	8.721806	11.278194	59
2	8.549995	9.999726	8.550268	11.449732	8.723595	9.999391	8.724254	11.275796	58
3	8.553558	9.999722	8.553817	11.446183	8.725972	9.999384	8.726588	11.273412	57
4	8.557014	9.999717	8.557336	11.442664	8.728336	9.999378	8.728959	11.271041	56
5	8.560540	9.999713	8.560827	11.439172	8.730688	9.999371	8.731317	11.268683	55
6	8.563999	9.999708	8.564291	11.435709	8.733027	9.999364	8.733663	11.266337	54
7	8.567431	9.999703	8.567727	11.432272	8.735354	9.999357	8.735996	11.264004	53
8	8.570836	9.999699	8.571137	11.428863	8.737667	9.999350	8.738317	11.261683	52
9	8.574214	9.999694	8.574520	11.425480	8.739969	9.999343	8.740626	11.259374	51
10	8.577566	9.999689	8.577877	11.422123	8.742259	9.999336	8.742922	11.257078	50
11	8.580892	9.999685	8.581208	11.418792	8.744536	9.999329	8.745207	11.254793	49
12	8.584193	9.999680	8.584514	11.415486	8.746801	9.999321	8.747479	11.252521	48
13	8.587469	9.999675	8.587795	11.412205	8.745955	9.999315	8.749740	11.250240	47
14	8.590721	9.999670	8.591051	11.408949	8.751297	9.999308	8.751989	11.248011	46
15	8.593948	9.999665	8.594283	11.405717	8.753528	9.999301	8.754227	11.245773	45
16	8.597152	9.999660	8.597492	11.402508	8.755747	9.999294	8.756453	11.243547	44
17	8.600332	9.999655	8.600977	11.399323	8.757955	9.999286	8.758668	11.241332	43
18	8.603488	9.999650	8.603838	11.396161	8.760151	9.999279	8.760872	11.239128	42
19	8.606622	9.999645	8.606978	11.393022	8.762337	9.999272	8.763065	11.236935	41
20	8.609734	9.999640	8.610094	11.389906	8.764511	9.999265	8.765246	11.234754	40
21	8.612823	9.999635	8.613189	11.386811	8.766675	9.999257	8.767417	11.232583	39
22	8.615891	9.999629	8.616262	11.383738	8.768828	9.999250	8.769578	11.230422	38
23	8.618937	9.999624	8.619313	11.380687	8.770970	9.999242	8.771727	11.228273	37
24	8.621967	9.999619	8.622343	11.377657	8.773101	9.999235	8.773866	11.229134	36
25	8.624965	9.999614	8.625352	11.374648	8.775223	9.999227	8.775995	11.224005	35
26	8.627948	9.999608	8.628340	11.371660	8.777333	9.999220	8.778114	11.221886	34
27	8.630911	9.999603	8.631308	11.368691	8.779434	9.999212	8.783222	11.219778	33
28	8.633854	9.999597	8.634456	11.365744	8.781524	9.999204	8.782320	11.217680	32
29	8.636776	9.999592	8.637184	11.362816	8.783605	9.999197	8.784404	11.215592	31
30	8.639679	9.999586	8.640093	11.359907	8.785675	9.999189	8.786486	11.213514	30
31	8.642563	9.999581	8.642982	11.357017	8.787736	9.999181	8.788554	11.211446	29
32	8.645428	9.999575	8.645853	11.354147	8.789787	9.999174	8.790613	11.209387	28
33	8.648274	9.999570	8.648704	11.351296	8.791828	9.999166	8.792662	11.207338	27
34	8.651102	9.999564	8.651538	11.348463	8.793859	9.999158	8.794701	11.205299	26
35	8.653911	9.999558	8.654352	11.345648	8.795881	9.999150	8.796731	11.203269	25
36	8.656702	9.999553	8.657149	11.342851	8.797894	9.999142	8.798752	11.201248	24
37	8.659475	9.999547	8.659928	11.340072	8.799897	9.999134	8.800763	11.199237	23
38	8.662230	9.999541	8.662689	11.337311	8.801891	9.999126	8.802765	11.197235	22
39	8.664968	9.999535	8.665433	11.334567	8.803876	9.999118	8.807458	11.195242	21
40	8.667689	9.999529	8.668160	11.331840	8.805852	9.999110	8.806741	11.193258	20
41	8.670393	9.999523	8.670869	11.329130	8.807819	9.999102	8.808717	11.191283	19
42	8.673080	9.999518	8.673563	11.326437	8.809777	9.999094	8.811683	11.189317	18
43	8.675751	9.999512	8.676239	11.323761	8.811726	9.999086	8.812641	11.187359	17
44	8.678405	9.999506	8.678899	11.321100	8.813667	9.999077	8.814589	11.185411	16
45	8.681043	9.999499	8.641544	11.318456	8.815598	9.999069	8.816529	11.183471	15
46	8.683665	9.999493	8.684172	11.315828	8.817522	9.999061	8.818461	11.181539	14
47	8.686272	9.999487	8.686784	11.313216	8.819436	9.999052	8.820384	11.179616	13
48	8.688892	9.999481	8.689381	11.310619	8.821342	9.999044	8.822298	11.177702	12
49	8.691438	9.999475	8.691963	11.308037	8.823240	9.999036	8.824205	11.175795	11
50	8.693998	9.999469	8.694529	11.305471	8.825130	9.999027	8.826103	11.173897	10
51	8.696543	9.999462	8.697081	11.302919	8.827011	9.999019	8.827992	11.172008	9
52	8.699073	9.999456	8.699617	11.300383	8.828884	9.999010	8.829874	11.170126	8
53	8.701589	9.999450	8.702139	11.297861	8.830749	9.999002	8.831748	11.168252	7
54	8.704090	9.999443	8.704646	11.295354	8.832106	9.998993	8.833613	11.166387	6
55	8.706576	9.999437	8.707139	11.292860	8.834456	9.998984	8.835471	11.164529	5
56	8.709049	9.999431	8.709618	11.290381	8.836297	9.998976	8.837321	11.162679	4
57	8.711507	9.999424	8.712083	11.287917	8.838130	9.998967	8.839163	11.160837	3
58	8.713952	9.999418	8.714534	11.285466	8.839956	9.998958	8.840998	11.159002	2
59	8.716383	9.999411	8.716972	11.283028	8.841774	9.998940	8.842825	11.157175	1
60	8.718800	9.999404	8.719396	11.280604	8.843585	9.998941	8.844644	11.155356	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine*	Sine	*Co-tang.*	Tangent	M
	Degree 87.				Degree 86.				

Canon Triangulorum Logarithmicus.

Degree 4.

M	Sine	Co-sine	Tangent	Co-tang.	
0	8.843584	9.998941	8.844644	11.155356	
1	8.845387	9.998931	8.846455	11.153545	
2	8.847183	9.998923	8.848260	11.151740	
3	8.848971	9.998914	8.850057	11.149943	
4	8.850751	9.998905	8.851846	11.148154	
5	8.852525	9.998896	8.853628	11.146372	
6	8.854291	9.998887	8.855403	11.144597	
7	8.856049	9.998878	8.857171	11.142829	
8	8.857801	9.998869	8.858932	11.141068	
9	8.859546	9.998860	8.860686	11.139314	
10	8.861283	9.998851	8.862433	11.137567	
11	8.863014	9.998841	8.864173	11.135827	
12	8.864738	9.998832	8.865906	11.134094	
13	8.866454	9.998823	8.867632	11.132368	
14	8.868165	9.998813	8.869351	11.130649	
15	8.869868	9.998804	8.871064	11.128936	
16	8.871565	9.998795	8.872770	11.127230	
17	8.873255	9.998785	8.874469	11.125531	
18	8.874938	9.998776	8.876162	11.123838	
19	8.876615	9.998766	8.877849	11.122151	
20	8.878285	9.998757	8.879529	11.120471	
21	8.879949	9.998747	8.881202	11.118798	
22	8.881607	9.998738	8.882869	11.117131	
23	8.883258	9.998728	8.884530	11.115470	
24	8.884903	9.998718	8.886185	11.113815	
25	8.886542	9.998708	8.887833	11.112167	
26	8.888174	9.998699	8.889476	11.110524	
27	8.889801	9.998689	8.891112	11.108888	
28	8.891421	9.998679	8.892742	11.107258	
29	8.893035	9.998669	8.894366	11.105634	
30	8.894643	9.998659	8.895984	11.104016	
31	8.896246	9.998649	8.897596	11.102404	
32	8.897842	9.998639	8.899203	11.100797	
33	8.899432	9.998629	8.900803	11.099197	
34	8.901017	9.998619	8.902398	11.097601	
35	8.902596	9.998609	8.903987	11.096013	
36	8.904169	9.998599	8.905570	11.094430	
37	8.905736	9.998589	8.907147	11.092853	
38	8.907297	9.998577	8.908719	11.091281	
39	8.908853	9.998568	8.910285	11.089715	
40	8.910404	9.998558	8.911846	11.088154	
41	8.911949	9.998548	8.913401	11.086599	
42	8.913488	9.998537	8.914951	11.085049	
43	8.915022	9.998527	8.916495	11.083505	
44	8.916550	9.998516	8.918034	11.081966	
45	8.918073	9.998506	8.919568	11.080432	
46	8.919591	9.998495	8.921096	11.078904	
47	8.921103	9.998485	8.922619	11.077381	
48	8.922610	9.998474	8.924136	11.075864	
49	8.924112	9.998464	8.925649	11.074351	
50	8.925609	9.998453	8.927156	11.072844	
51	8.927100	9.998442	8.928658	11.071342	
52	8.928587	9.998431	8.930155	11.069845	
53	8.930068	9.998421	8.931647	11.068353	
54	8.931544	9.998410	8.933134	11.066866	
55	8.933015	9.998399	8.934616	11.065384	
56	8.934481	9.998388	8.936093	11.063907	
57	8.935942	9.998377	8.937565	11.062435	
58	8.937398	9.998366	8.939032	11.060968	
59	8.938850	9.998355	8.940494	11.059506	
60	8.940296	9.998344	8.941951	11.058048	
	Co-sine	Sine	Co-tang.	Tangent	

Degree 85.

Degree 5.

Sine	Co-sine	Tangent	Co-tang.	
8.940296	9.998344	8.941952	11.058048	60
8.941738	9.998333	8.943404	11.056596	59
8.943174	9.998322	8.944852	11.055148	58
8.944606	9.998311	8.946295	11.053705	57
8.946034	9.998300	8.947734	11.052266	56
8.957456	9.998289	8.949168	11.050832	55
8.958814	9.998277	8.950597	11.049403	54
8.950287	9.998265	8.952021	11.047979	53
8.951696	9.998255	8.953441	11.046559	52
8.953099	9.998243	8.954856	11.045144	51
8.954499	9.998232	8.956267	11.043733	50
8.955894	9.998220	8.957674	11.042326	49
8.957284	9.998209	8.959075	11.040925	48
8.958670	9.998197	8.960473	11.039527	47
8.960052	9.998186	8.961866	11.038134	46
8.961429	9.998174	8.963254	11.036746	45
8.962801	9.998163	8.964639	11.035361	44
8.964170	9.998151	8.966019	11.033981	43
8.965534	9.998139	8.967394	11.032606	42
8.966893	9.998128	8.968766	11.031234	41
8.968249	9.998106	8.970133	11.029867	40
8.969600	9.998104	8.971495	11.028505	39
8.970947	9.998092	8.972855	11.027145	38
8.972289	9.998080	8.974209	11.025791	37
8.973626	9.998068	8.975560	11.024440	36
8.974962	9.998056	8.976906	11.023094	35
8.976293	9.998044	8.978248	11.021752	34
8.977619	9.998032	8.979586	11.020414	33
8.978941	9.998020	8.980921	11.019079	32
8.980259	9.998008	8.982251	11.017749	31
8.981573	9.997996	8.983577	11.016423	30
8.982883	9.997984	8.984899	11.015101	29
8.984189	9.997971	8.986217	11.013783	28
8.985491	9.997959	8.987532	11.012468	27
8.986789	9.997947	8.988842	11.011158	26
8.988083	9.997935	8.990149	11.009851	25
8.989374	9.997922	8.991451	11.008549	24
8.990660	9.997910	8.992750	11.007250	23
8.991943	9.997897	8.994045	11.005955	22
8.993228	9.997885	8.995337	11.004663	21
8.994497	9.997873	8.996624	11.003376	20
8.995768	9.997860	8.997908	11.002092	19
8.997036	9.997847	8.999188	11.000811	18
8.998299	9.997835	9.000465	10.999535	17
8.999560	9.997822	9.001738	10.998262	16
9.000816	9.997809	9.003007	10.996993	15
9.002069	9.997797	9.004272	10.995728	14
9.003318	9.997784	9.005534	10.994466	13
9.004563	9.997771	9.006792	10.993208	12
9.005805	9.997758	9.008047	10.991953	11
9.007044	9.997732	9.009298	10.990702	10
9.008278	9.997732	9.010546	10.989454	9
9.009510	9.997719	9.011790	10.988210	8
9.010737	9.997706	9.013031	10.986969	7
9.011961	9.997693	9.014268	10.985732	6
9.013181	9.997680	9.015502	10.984498	5
9.014399	9.997667	9.016732	10.983268	4
9.015613	9.997654	9.017959	10.982041	3
9.016824	9.997641	9.019183	10.980817	2
9.018031	9.997628	9.020403	10.979597	1
9.019235	9.997614	9.021620	10.978380	0
Co-sine	Sine	Co-tang	Tangent	M

Degree 84.

Canon Triangulorum Logarithmicus.

Degree 6.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.019235	9.997614	9.021620	10.978380
1	9.020435	9.997601	9.022834	10.977166
2	9.021632	9.997588	9.024044	10.975956
3	9.022825	9.997574	9.025251	10.974749
4	9.024016	9.997561	9.026455	10.973545
5	9.025203	9.997548	9.027655	10.972345
6	9.026386	9.997534	9.028852	10.971148
7	9.027567	9.997520	9.030046	10.969954
8	9.028744	9.997507	9.031237	10.968763
9	9.029918	9.997493	9.032425	10.967575
10	9.031089	9.997480	9.033609	10.966391
11	9.032257	9.997466	9.034791	10.965209
12	9.033421	9.997452	9.035969	10.964031
13	9.034582	9.997439	9.037144	10.962856
14	9.035741	9.997425	9.038316	10.961684
15	9.036896	9.997411	9.039485	10.960515
16	9.038048	9.997397	9.040651	10.959349
17	9.039197	9.997383	9.041813	10.958187
18	9.040342	9.997369	9.042973	10.957027
19	9.041485	9.997355	9.044130	10.955870
20	9.042625	9.997341	9.045284	10.954716
21	9.043762	9.997327	9.046434	10.953566
22	9.044895	9.997313	9.047582	10.952418
23	9.046026	9.997299	9.048727	10.951273
24	9.047154	9.997285	9.049869	10.950131
25	9.048279	9.997271	9.051008	10.948992
26	9.049400	9.997256	9.052144	10.947856
27	9.050519	9.997242	9.053277	10.946723
28	9.051635	9.997228	9.054408	10.945592
29	9.052749	9.997214	9.055535	10.944465
30	9.053859	9.997199	9.056640	10.943340
31	9.054966	9.997185	9.057781	10.942219
32	9.056071	9.997170	9.058900	10.941100
33	9.057172	9.997156	9.060016	10.939984
34	9.058271	9.997141	9.061130	10.938870
35	9.059367	9.997127	9.062240	10.937760
36	9.060460	9.997112	9.063348	10.936652
37	9.061551	9.997098	9.064453	10.935547
38	9.062638	9.997083	9.065556	10.934444
39	9.063723	9.997068	9.066655	10.933345
40	9.064806	9.997053	9.067752	10.932248
41	9.065885	9.997039	9.068847	10.931153
42	9.066962	9.997024	9.069938	10.930062
43	9.068036	9.997009	9.071027	10.928973
44	9.069107	9.996994	9.072113	10.927887
45	9.070176	9.996979	9.073197	10.926803
46	9.071241	9.996964	9.074278	10.925722
47	9.072306	9.996949	9.075356	10.924644
48	9.073366	9.996934	9.076432	10.923568
49	9.074424	9.996919	9.077505	10.922495
50	9.075480	9.996904	9.078576	10.921424
51	9.076533	9.996889	9.079644	10.920356
52	9.077583	9.996874	9.080710	10.919290
53	9.078631	9.996858	9.081773	10.918227
54	9.079676	9.996843	9.082833	10.917167
55	9.080719	9.996828	9.083891	10.916109
56	9.081759	9.996812	9.084947	10.915053
57	9.082797	9.996797	9.085999	10.914000
58	9.083832	9.996782	9.087050	10.912950
59	9.084864	9.996766	9.088098	10.911902
60	9.085894	9.996751	9.089144	10.910856
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 83.

Degree 7.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.085894	9.996751	9.089144	10.910856	60
9.086922	9.996735	9.090187	10.909813	59
9.087947	9.996720	9.091228	10.908772	58
9.088970	9.996704	9.092266	10.907734	57
9.089990	9.996688	9.093301	10.906698	56
9.091088	9.996673	9.094336	10.905664	55
9.092024	9.996657	9.095367	10.904633	54
9.093037	9.996641	9.096395	10.903604	53
9.094047	9.996625	9.097422	10.902578	52
9.095056	9.996610	9.098446	10.901554	51
9.096062	9.996594	9.099468	10.900532	50
9.097065	9.996578	9.100487	10.899513	49
9.098066	9.996562	9.101504	10.898496	48
9.099065	9.996546	9.102519	10.897481	47
9.100062	9.996530	9.103532	10.896468	46
9.101056	9.996514	9.104542	10.895458	45
9.102048	9.996498	9.105550	10.894450	44
9.103037	9.996482	9.106556	10.893444	43
9.104025	9.996465	9.107559	10.892441	42
9.105010	9.996449	9.108560	10.891440	41
9.105992	9.996433	9.109559	10.890441	40
9.106973	9.996417	9.110556	10.889444	39
9.107951	9.996400	9.111551	10.888449	38
9.108927	9.996384	9.112543	10.887457	37
9.109901	9.996368	9.113533	10.886467	36
9.110873	9.996351	9.114521	10.885478	35
9.111842	9.996335	9.115507	10.884493	34
9.112809	9.996318	9.116491	10.883509	33
9.113774	9.996302	9.117472	10.882528	32
9.114737	9.996285	9.118452	10.881548	31
9.115698	9.996269	9.119429	10.880571	30
9.116656	9.996252	9.120404	10.879596	29
9.116612	9.996235	9.121377	10.878623	28
9.118567	9.996218	9.122348	10.877652	27
9.119519	9.996202	9.123317	10.876683	26
9.120469	9.996185	9.124284	10.875716	25
9.121417	9.996168	9.125248	10.874751	24
9.122362	9.996151	9.126211	10.873789	23
9.123306	9.996134	9.127172	10.872828	22
9.124248	9.996117	9.128130	10.871870	21
9.125187	9.996100	9.129087	10.870913	20
9.126125	9.996083	9.130041	10.869959	19
9.127060	9.996066	9.130994	10.869006	18
9.127993	9.996049	9.131944	10.868056	17
9.128925	9.996032	9.132893	10.867107	16
9.129854	9.996015	9.133839	10.866161	15
9.130781	9.995998	9.134784	10.865216	14
9.131706	9.995980	9.135726	10.864274	13
9.132630	9.995963	9.136666	10.863334	12
9.133551	9.995946	9.137605	10.862395	11
9.134470	9.995928	9.138542	10.861458	10
9.135387	9.995911	9.139476	10.860524	9
9.136303	9.995894	9.140409	10.859591	8
9.137216	9.995876	9.141340	10.858660	7
9.138127	9.995859	9.142269	10.857731	6
9.139037	9.995841	9.143196	10.856804	5
9.139944	9.995825	9.144121	10.855879	4
9.140850	9.995806	9.145044	10.854956	3
9.141754	9.995783	9.145965	10.854035	2
9.142655	9.995770	9.146885	10.853115	1
9.143555	9.995753	9.147803	10.852197	0
Co-sine	Sine.	*Co-tang*	Tangent	M

Degree 82.

Canon Triangulorum Logarithmicus.

Degree 8.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.143555	9.995753	9.147803	10.852197
1	9.144453	9.995735	9.148718	10.851282
2	9.145349	9.995717	9.149632	10.850368
3	9.146243	9.995699	9.150544	10.849456
4	9.147136	9.995681	9.151454	10.848546
5	9.148026	9.995664	9.152363	10.847637
6	9.148915	9.995646	9.153269	10.846731
7	9.149801	9.995628	9.154174	10.845825
8	9.150686	9.995610	9.155077	10.844923
9	9.151569	9.995591	9.155978	10.844022
10	9.152451	9.995573	9.156877	10.843123
11	9.153330	9.995555	9.157775	10.842225
12	9.154208	9.995537	9.158671	10.841329
13	9.155082	9.995519	9.159565	10.840435
14	9.155957	9.995501	9.160457	10.839543
15	9.156830	9.995482	9.161347	10.838653
16	9.157700	9.995464	9.162236	10.837764
17	9.158569	9.995446	9.163123	10.836877
18	9.159436	9.995427	9.164008	10.835992
19	9.160301	9.995409	9.164892	10.835108
20	9.161164	9.995390	9.165773	10.834226
21	9.162025	9.995372	9.166654	10.833346
22	9.162885	9.995353	9.167532	10.832468
23	9.163743	9.995334	9.168409	10.831591
24	9.164600	9.995316	9.169284	10.830716
25	9.165454	9.995297	9.170157	10.829843
26	9.166307	9.995278	9.171029	10.828971
27	9.167158	9.995260	9.171899	10.828101
28	9.168008	9.995241	9.172767	10.827233
29	9.168856	9.995222	9.173634	10.826366
30	9.169702	9.995203	9.174499	10.825501
31	9.170546	9.995184	9.175362	10.824638
32	9.171389	9.995165	9.176224	10.823776
33	9.172230	9.995146	9.177084	10.822916
34	9.173070	9.995127	9.177942	10.822057
35	9.173908	9.995108	9.178799	10.821201
36	9.174744	9.995089	9.179655	10.820345
37	9.175578	9.995070	9.180508	10.819492
38	9.176411	9.995061	9.181360	10.818640
39	9.177242	9.995032	9.182211	10.817789
40	9.178072	9.995012	9.183060	10.816940
41	9.178900	9.994993	9.183907	10.816093
42	9.179726	9.994974	9.184752	10.815248
43	9.180551	9.994955	9.185597	10.814403
44	9.181374	9.994935	9.186439	10.813561
45	9.182196	9.994916	9.187280	10.812720
46	9.183016	9.994896	9.188120	10.811880
47	9.183834	9.994876	9.188957	10.811042
48	9.184651	9.994857	9.189794	10.810206
49	9.185466	9.994838	9.190629	10.809371
50	9.186280	9.994818	9.191461	10.808538
51	9.187092	9.994798	9.192294	10.807706
52	9.187903	9.994779	9.193124	10.806876
53	9.188712	9.994759	9.193953	10.806047
54	9.189519	9.994739	9.194780	10.805220
55	9.190325	9.994719	9.195606	10.804394
56	9.191130	9.994699	9.196440	10.803569
57	9.191933	9.994680	9.197253	10.802747
58	9.192734	9.994660	9.198074	10.801926
59	9.193534	9.994640	9.198894	10.801106
60	9.194332	9.994620	9.199712	10.800287
	Co-sine	Sine	Co-tang.	Tangent

Degree 81.

Degree 9.

Sine	Co-sine	Tangent	Co-tang.	
9.194332	9.994620	9.199712	10.800287	60
9.195129	9.994600	9.200529	10.799470	59
9.195925	9.994580	9.201345	10.798655	58
9.196718	9.994560	9.202159	10.797841	57
9.197511	9.994540	9.202971	10.797029	56
9.198302	9.994519	9.203782	10.796218	55
9.199091	9.994499	9.204592	10.795408	54
9.199879	9.994479	9.205400	10.794600	53
9.200666	9.994459	9.206207	10.793793	52
9.201451	9.994438	9.207013	10.792987	51
9.202234	9.994418	9.207817	10.792183	50
9.203017	9.994398	9.208619	10.791381	49
9.203797	9.994377	9.209420	10.790580	48
9.204577	9.994357	9.210220	10.789780	47
9.205354	9.994336	9.211018	10.788982	46
9.206131	9.994316	9.211815	10.788185	45
9.206906	9.994295	9.212611	10.787389	44
9.207679	9.994274	9.213405	10.786595	43
9.208452	9.994254	9.214198	10.785802	42
9.209222	9.994233	9.214989	10.785011	41
9.209992	9.994212	9.215780	10.784220	40
9.210760	9.994191	9.216568	10.783432	39
9.211526	9.994171	9.217356	10.782644	38
9.212291	9.994150	9.218142	10.781858	37
9.213055	9.994129	9.218926	10.781074	36
9.213818	9.994108	9.219710	10.780290	35
9.214579	9.994087	9.220491	10.779508	34
9.215338	9.994066	9.221272	10.778728	33
9.216097	9.994044	9.222052	10.777948	32
9.216854	9.994024	9.222830	10.777170	31
9.217609	9.994003	9.223607	10.776393	30
9.218363	9.993982	9.224382	10.775618	29
9.219116	9.993960	9.225156	10.774844	28
9.219868	9.993939	9.225929	10.774071	27
9.220618	9.993918	9.226704	10.773300	26
9.221367	9.993897	9.227471	10.772529	25
9.222115	9.993875	9.228240	10.771760	24
9.222861	9.993854	9.229007	10.770993	23
9.223606	9.993832	9.229774	10.770226	22
9.224349	9.993811	9.230539	10.769461	21
9.225092	9.993789	9.231302	10.768698	20
9.225833	9.993768	9.232065	10.767935	19
9.226573	9.993746	9.232826	10.767174	18
9.227311	9.993725	9.233586	10.766414	17
9.228048	9.993703	9.234345	10.765655	16
9.228784	9.993681	9.235103	10.764897	15
9.229518	9.993660	9.235859	10.764141	14
9.230252	9.993638	9.236614	10.763386	13
9.230984	9.993516	9.237368	10.762632	12
9.231715	9.993594	9.238120	10.761880	11
9.232444	9.993572	9.238872	10.761128	10
9.233172	9.993550	9.239622	10.760378	9
9.233899	9.993528	9.240371	10.759629	8
9.234625	9.993506	9.241118	10.758882	7
9.235349	9.993484	9.241865	10.758135	6
9.236073	9.993462	9.242610	10.757390	5
9.236795	9.993440	9.243354	10.756646	4
9.237515	9.993418	9.244097	10.755903	3
9.238835	9.993396	9.244839	10.755161	2
9.238952	9.993374	9.245579	10.754421	1
9.239670	9.993351	9.246319	10.753681	0
Co-sine	Sine	Co-tang	Tangent	M

Degree 80.

Canon Triangulorum Logarithmicus.

Degree 10.				
M	Sine	*Co-sine.*	Tangent	*Co-tang.*
0	9.239670	9.993351	9.246319	10.753681
1	9.240386	9.993329	9.247057	10.752943
2	9.241101	9.993307	9.247794	10.752206
3	9.241814	9.993284	9.248530	10.751470
4	9.242526	9.993262	9.249264	10.750736
5	9.243237	9.993240	9.249998	10.750002
6	9.243947	9.993117	9.250730	10.749270
7	9.244656	9.993195	9.251461	10.748539
8	9.245363	9.993172	9.252191	10.747809
9	9.246070	9.993149	9.252920	10.747080
10	9.246775	9.993127	9.253648	10.746352
11	9.247478	9.993104	9.254374	10.745626
12	9.248181	9.993011	9.255200	10.744900
13	9.248883	9.993059	9.255824	10.744176
14	9.249583	9.993036	9.256547	10.743453
15	9.250282	9.993013	9.257269	10.742731
16	9.250980	9.992990	9.257990	10.742010
17	9.251677	9.992967	9.258710	10.741290
18	9.252373	9.992944	9.259429	10.740571
19	9.253067	9.992921	9.260146	10.739854
20	9.253761	9.992898	9.260863	10.739137
21	9.254453	9.992875	9.261578	10.738422
22	9.255144	9.992852	9.262292	10.737708
23	9.255834	9.992829	9.263005	10.736995
24	9.256523	9.992806	9.263717	10.736283
25	9.257211	9.992783	9.264428	10.735572
26	9.257898	9.992759	9.265138	10.734862
27	9.258583	9.992736	9.265847	10.734153
28	9.259268	9.992713	9.266555	10.733445
29	9.259951	9.992690	9.267261	10.732739
30	9.260633	9.992666	9.267967	10.732033
31	9.261314	9.992643	9.268671	10.731329
32	9.261994	9.992619	9.269375	10.730625
33	9.262673	9.992596	9.270078	10.729923
34	9.263351	9.992572	9.271479	10.729221
35	9.264027	9.992549	9.271479	10.728521
36	9.264703	9.992525	9.272178	10.727822
37	9.265378	9.992501	9.272876	10.727124
38	9.266051	9.992478	9.273573	10.726427
39	9.266723	9.992454	9.274269	10.725731
40	9.267395	9.992430	9.274964	10.725036
41	9.268065	9.992406	9.275658	10.724342
42	9.268734	9.992382	9.276351	10.723649
43	9.269402	9.992362	9.277043	10.722957
44	9.270069	9.992335	9.277734	10.722267
45	9.270735	9.992311	9.278424	10.721576
46	9.271400	9.992287	9.279113	10.720887
47	9.272063	9.992263	9.279801	10.720199
48	9.272726	9.992239	9.280488	10.719512
49	9.273388	9.992214	9.281174	10.718826
50	9.274049	9.992190	9.281858	10.718142
51	9.274708	9.992166	9.282542	10.717458
52	9.275367	9.992142	9.283225	10.716775
53	9.276025	9.992118	9.283907	10.716093
54	9.276681	9.992093	9.284588	10.715412
55	9.277337	9.992069	9.285268	10.714732
56	9.277991	9.992045	9.285946	10.714053
57	9.278685	9.992020	9.286624	10.713376
58	9.279297	9.991996	9.287301	10.712699
59	9.279948	9.991971	9.287977	10.712023
60	9.280599	9.991947	9.288652	10.711348
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 79.

Degree 11.				
Sine	*Co-sine*	Tangent	*Co-tang.*	
9.280599	9.991947	9.288652	10.711348	60
9.281229	9.991922	9.289326	10.710674	59
9.281897	9.991897	9.289999	10.710001	58
9.282544	9.991873	9.290671	10.709329	57
9.283190	9.991848	9.291342	10.708658	56
9.283836	9.991823	9.292013	10.707987	55
9.284480	9.991799	9.292682	10.707318	54
9.285124	9.991774	9.293350	10.706650	53
9.285766	9.991749	9.294017	10.705983	52
9.286408	9.991724	9.294684	10.705316	51
9.287048	9.991699	9.295349	10.704651	50
9.287688	9.991674	9.296013	10.703987	49
9.288326	9.991649	9.296677	10.703323	48
9.288964	9.991624	9.297339	10.702661	47
9.289600	9.991599	9.298001	10.701999	46
9.290236	9.991574	9.298661	10.701338	45
9.290870	9.991549	9.299322	10.700678	44
9.291504	9.991524	9.299980	10.700020	43
9.292137	9.991498	9.300638	10.699362	42
9.292788	9.991473	9.301295	10.698705	41
9.293399	9.991448	9.301951	10.698049	40
9.294029	9.991422	9.302607	10.697393	39
9.294658	9.991397	9.303261	10.696739	38
9.295286	9.991372	9.303914	10.696086	37
9.295913	9.991346	9.304567	10.695433	36
9.296539	9.991321	9.305218	10.694782	35
9.297164	9.991295	9.305867	10.694131	34
9.297788	9.991270	9.306519	10.693481	33
9.298412	9.991244	9.307168	10.692832	32
9.299034	9.991218	9.307816	10.692184	31
9.299655	9.991193	9.308463	10.691537	30
9.300276	9.991167	9.309109	10.690891	29
9.300895	9.991141	9.309754	10.690246	28
9.301514	9.991115	9.310399	10.689601	27
9.302132	9.991090	9.311042	10.688958	26
9.302749	9.991064	9.311685	10.688315	25
9.303364	9.991038	9.312327	10.687673	24
9.303979	9.991012	9.312968	10.687032	23
9.304593	9.990986	9.313608	10.686392	22
9.305207	9.990960	9.314247	10.685753	21
9.305819	9.990934	9.314885	10.685115	20
9.306430	9.990908	9.315523	10.684477	19
9.307041	9.990882	9.316159	10.683841	18
9.307650	9.990855	9.316795	10.683205	17
9.308259	9.990829	9.317430	10.682570	16
9.308867	9.990803	9.318064	10.681936	15
9.309474	9.990777	9.318697	10.681303	14
9.310080	9.990750	9.319330	10.680670	13
9.310685	9.990724	9.319961	10.680039	12
9.311289	9.990697	9.320592	10.679408	11
9.311899	9.990671	9.321222	10.678778	10
9.312495	9.990645	9.321851	10.678149	9
9.313097	9.990618	9.322479	10.677521	8
9.313698	9.990591	9.323106	10.676894	7
9.314297	9.990565	9.323733	10.676267	6
9.314897	9.990538	9.324358	10.675642	5
9.315495	9.990512	9.324983	10.675017	4
9.316092	9.990485	9.325607	10.674393	3
9.316689	9.990458	9.326231	10.673769	2
9.317284	9.990431	9.326853	10.673147	1
9.317879	9.990404	9.327475	10.672525	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 78.

Canon Triangulorum Logarithmicus.

Degree 12.

M	Sine	*Co-sine.*	Tangent	*Co-tang.*
0	9.317879	9.990404	9.327475	10.672525
1	9.318473	9.990377	9.328095	10.671905
2	9.319066	9.990351	9.328715	10.671285
3	9.319658	9.990324	9.329334	10.670666
4	9.320250	9.990297	9.329953	10.670047
5	9.320840	9.990270	9.320570	10.669430
6	9.321430	9.990242	9.331187	10.668813
7	9.322019	9.990215	9.331803	10.668197
8	9.322607	9.990188	9.332418	10.667582
9	9.323194	9.990161	9.333033	10.666967
10	9.323780	9.990134	9.333646	10.666354
11	9.324366	9.990107	9.334259	10.665741
12	9.324950	9.990079	9.334871	10.665129
13	9.325534	9.990052	9.335482	10.664518
14	9.326117	9.990025	9.336093	10.663907
15	9.326699	9.989997	9.336701	10.663298
16	9.327281	9.989970	9.337311	10.662689
17	9.327862	9.989942	9.337919	10.662081
18	9.328441	9.989915	9.338527	10.661473
19	9.329020	9.989887	9.339133	10.660867
20	9.329599	9.989860	9.339739	10.660261
21	9.330176	9.989832	9.340344	10.659656
22	9.330753	9.989804	9.340948	10.659052
23	9.331328	9.989777	9.341552	10.658448
24	9.331903	9.989749	9.342155	10.657845
25	9.332478	9.989721	9.342757	10.657243
26	9.333051	9.989693	9.343358	10.656642
27	9.333624	9.989665	9.343958	10.656042
28	9.334195	9.989637	9.344558	10.655442
29	9.334766	9.989609	9.345157	10.654843
30	9.335337	9.989581	9.345755	10.654245
31	9.335906	9.989553	9.346353	10.653647
32	9.336475	9.989525	9.346949	10.653051
33	9.337043	9.989597	9.347545	10.652455
34	9.337610	9.989469	9.348141	10.651859
35	9.338176	9.989441	9.348735	10.651265
36	9.338742	9.989413	9.349329	10.650671
37	9.339306	9.989384	9.349922	10.650078
38	9.339870	9.989356	9.350514	10.649486
39	9.340434	9.989328	9.351106	10.648894
40	9.340996	9.989299	9.351697	10.648303
41	9.341558	9.989271	9.352287	10.647713
42	9.342119	9.989243	9.352876	10.647124
43	9.342679	9.989214	9.353465	10.646535
44	9.343239	9.989186	9.354053	10.645947
45	9.343797	9.989157	9.354640	10.645360
46	9.344355	9.989128	9.355227	10.644773
47	9.344912	9.989100	9.355812	10.644187
48	9.345469	9.989071	9.356398	10.643602
49	9.346024	9.989042	9.356982	10.643018
50	9.346579	9.989014	9.357566	10.642434
51	9.347134	9.988985	9.358149	10.641851
52	9.347687	9.988956	9.358731	10.641269
53	9.348240	9.988927	9.359313	10.640687
54	9.348792	9.988898	9.359893	10.640107
55	9.349343	9.988869	9.360474	10.639526
56	9.349893	9.988840	9.361053	10.638947
57	9.350443	9.988811	9.361632	10.638368
58	9.350992	9.988782	9.362210	10.637790
59	9.351540	9.988754	9.362787	10.637213
60	9.352088	9.988724	9.363364	10.636636

Co sine	Sine	*Co-tang.*	Tangent

Degree 77.

Degree 13.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.352088	9.988724	9.363364	10.636636	60
9.352635	9.988695	9.363940	10.636060	59
9.353181	9.988666	9.364515	10.635485	58
9.353726	9.988636	9.365090	10.634910	57
9.354271	9.988607	9.365664	10.634336	56
9.354185	9.988578	9.366237	10.633763	55
9.355358	9.988548	9.366810	10.633190	54
9.355901	9.988519	9.367382	10.632618	53
9.356443	9.988489	9.367953	10.632047	52
9.356984	9.988460	9.368524	10.631476	51
9.357524	9.988430	9.369094	10.630906	50
9.358064	9.988401	9.369663	10.630337	49
9.358603	9.988371	9.370232	10.629768	48
9.359141	9.988341	9.370799	10.629201	47
9.359679	9.988312	9.371367	10.628633	46
9.350215	9.988282	9.371933	10.628067	45
9.360752	9.988252	9.372499	10.627501	44
9.361287	9.988223	9.373064	10.626936	43
9.361822	9.988193	9.373629	10.626371	42
9.362356	9.988163	9.374193	10.625807	41
9.362889	9.988133	9.374756	10.625244	40
9.363422	9.988103	9.375319	10.624681	39
9.363954	9.988073	9.375881	10.624119	38
9.364485	9.988043	9.376442	10.623558	37
9.365016	9.988013	9.377003	10.622997	36
9.365546	9.987983	9.377563	10.622437	35
9.366075	9.987953	9.378122	10.621878	34
9.366604	9.987922	9.378681	10.621319	33
9.367132	9.987892	9.379239	10.620761	32
9.367659	9.987862	9.379797	10.620203	31
9.368185	9.987832	9.380354	10.619646	30
9.368711	9.987801	9.380910	10.619090	29
9.369236	9.987771	9.381466	10.618534	28
9.369761	9.987740	9.382021	10.617980	27
9.370285	9.987710	9.382575	10.617425	26
9.370808	9.987679	9.383129	10.616871	25
9.371330	9.987649	9.383682	10.616318	24
9.371852	9.987618	9.384234	10.615766	23
9.372373	9.987588	9.384786	10.615214	22
9.372894	9.987557	9.385337	10.614663	21
9.373414	9.987526	9.385888	10.614112	20
9.373933	9.987496	9.386438	10.613562	19
9.374452	9.987465	9.386987	10.613013	18
9.374970	9.987434	9.387536	10.612464	17
9.375487	9.987403	9.388084	10.611916	16
9.376003	9.987372	9.388631	10.611369	15
9.376519	9.987341	9.389178	10.610822	14
9.377035	9.987310	9.389724	10.610276	13
9.377549	9.987279	9.390270	10.609730	12
9.378063	9.987248	9.390815	10.609185	11
9.378577	9.987217	9.391360	10.608640	10
9.379089	9.987186	9.391907	10.608097	9
9.379601	9.987155	9.392467	10.607553	8
9.380113	9.987124	9.392989	10.607011	7
9.380624	9.987092	9.393531	10.606469	6
9.381134	9.987061	9.394074	10.605927	5
9.381643	9.987030	9.394614	10.605386	4
9.382152	9.986998	9.395154	10.604846	3
9.382661	9.986967	9.395694	10.604306	2
9.383168	9.986936	9.396233	10.603767	1
9.383675	9.986904	9.396771	10.603229	0

Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 76.

Degree 14.

M	Sine	Co-sine.	Tangent	Co-tang.
0	9.383675	9.986904	9.396771	10.603229
1	9.384181	9.986873	9.397309	10.602694
2	9.384687	9.986841	9.397846	10.602154
3	9.385192	9.986809	9.398383	10.601617
4	9.385697	9.986778	9.398919	10.601081
5	9.386201	9.986746	9.399455	10.600545
6	9.386704	9.986714	9.399990	10.600010
7	9.387207	9.986683	9.400524	10.599476
8	9.387709	9.986651	9.401058	10.598942
9	9.388210	9.986619	9.401591	10.598409
10	9.388711	9.986587	9.402124	10.597876
11	9.389211	9.986555	9.402656	10.597344
12	9.389711	9.986523	9.403187	10.596813
13	9.390210	9.986491	9.403718	10.596281
14	9.390708	9.986459	9.404249	10.595751
15	9.391206	9.986427	9.404778	10.595222
16	9.391703	9.986395	9.405306	10.594692
17	9.392199	9.986363	9.405836	10.594164
18	9.392695	9.986331	9.406364	10.593636
19	9.393190	9.986299	9.406892	10.593608
20	9.393685	9.986266	9.407419	10.592581
21	9.394179	9.986234	9.407945	10.592055
22	9.394673	9.986201	9.408471	10.591529
23	9.395166	9.986169	9.408996	10.591001
24	9.395654	9.986137	9.409521	10.590479
25	9.396150	9.986104	9.410045	10.589954
26	9.396641	9.986072	9.410569	10.589431
27	9.397131	9.986039	9.411092	10.588908
28	9.397621	9.986007	9.411615	10.588385
29	9.398111	9.985974	9.412137	10.587863
30	9.398600	9.985942	9.412658	10.587342
31	9.399087	9.985909	9.413179	10.586821
32	9.399575	9.985876	9.413699	10.586301
33	9.400062	9.985843	9.414219	10.585781
34	9.400549	9.985811	9.414738	10.585262
35	9.401035	9.985778	9.415257	10.584742
36	9.401520	9.985745	9.415775	10.584225
37	9.402005	9.985712	9.416293	10.583707
38	9.402489	9.985679	9.416810	10.583190
39	9.402972	9.985646	9.417326	10.582674
40	9.403455	9.985613	9.417842	10.582157
41	9.403938	9.985580	9.418357	10.581642
42	9.404420	9.985547	9.418873	10.581127
43	9.404901	9.985513	9.419387	10.580613
44	9.405382	9.985480	9.419901	10.580099
45	9.405861	9.985447	9.420415	10.579585
46	9.406341	9.985414	9.420927	10.579072
47	9.406820	9.985380	9.421440	10.578560
48	9.407299	9.985347	9.421951	10.578048
49	9.407776	9.985314	9.422463	10.577537
50	9.408254	9.985280	9.422973	10.577026
51	9.408731	9.985247	9.423484	10.576516
52	9.409207	9.985213	9.423993	10.576007
53	9.409682	9.985180	9.424503	10.575497
54	9.410157	9.985146	9.425011	10.574989
55	9.410632	9.985112	9.425518	10.574480
56	9.411106	9.985079	9.426027	10.573973
57	9.411579	9.985045	9.426534	10.573466
58	9.412052	9.985011	9.427041	10.572959
59	9.412524	9.984977	9.427547	10.572453
60	9.412996	9.984943	9.428052	10.571947

Co-sine	Sine	Co-tang	Tangent

Degree 75.

Degree 15.

Sine	Co-sine	Tangent	Co-tang.	
9.412996	9.984944	9.428052	10.571947	60
9.413467	9.984910	9.428557	10.571442	59
9.413938	9.984876	9.429062	10.570938	58
9.414408	9.984842	9.429566	10.570434	57
9.414878	9.984808	9.430070	10.569930	56
9.415347	9.984774	9.430573	10.569427	55
9.415815	9.984740	9.431075	10.568925	54
9.416283	9.984706	9.431577	10.568423	53
9.416850	9.984672	9.432079	10.567921	52
9.417217	9.984637	9.432580	10.567420	51
9.417684	9.984603	9.433080	10.566920	50
9.418149	9.984569	9.433580	10.566419	49
9.418615	9.984535	9.434080	10.565920	48
9.419079	9.984500	9.434579	10.565421	47
9.419544	9.984466	9.435078	10.564922	46
9.420007	9.984431	9.435576	10.564424	45
9.420470	9.984397	9.436073	10.563927	44
9.420933	9.984363	9.436570	10.563430	43
9.421395	9.984328	9.437067	10.562933	42
9.421856	9.984293	9.437563	10.562437	41
9.422317	9.984259	9.438059	10.561941	40
9.422778	9.984224	9.438554	10.561446	39
9.423238	9.984189	9.439548	10.560952	38
9.423697	9.984155	9.439543	10.560457	37
9.424156	9.984120	9.440036	10.559964	36
9.424615	9.984085	9.440529	10.55947	35
9.425072	9.984050	9.441022	10.558978	34
9.425530	9.984015	9.441514	10.558486	33
9.425987	9.983980	9.442006	10.557994	32
9.426443	9.983945	9.442497	10.557503	31
9.426899	9.983910	9.442988	10.557011	30
9.427354	9.983875	9.443479	10.556521	29
9.427809	9.983840	9.443968	10.556031	28
9.428264	9.983805	9.444458	10.555542	27
9.428717	9.983770	9.444947	10.555053	26
9.429170	9.983735	9.445435	10.554565	25
9.429623	9.983699	9.445923	10.554077	24
9.430075	9.983664	9.446411	10.553589	23
9.430507	9.983629	9.446898	10.553102	22
9.430978	9.983593	9.447384	10.552616	21
9.431429	9.983558	9.447870	10.552129	20
9.431879	9.983523	9.448356	10.551644	19
9.432328	9.983487	9.448841	10.551159	18
9.432778	9.983452	9.449326	10.550674	17
9.433206	9.983416	9.449870	10.550181	16
9.433674	9.983380	9.450294	10.549706	15
9.434122	9.983345	9.450777	10.549223	14
9.434569	9.983309	9.451260	10.548740	13
9.435016	9.983273	9.451743	10.548257	12
9.435462	9.983238	9.452225	10.547775	11
9.435918	9.983202	9.452706	10.547294	10
9.436353	9.983166	9.453187	10.546813	9
9.436798	9.983130	9.453668	10.546332	8
9.437242	9.983094	9.454148	10.545852	7
9.437686	9.983058	9.454629	10.545372	6
9.438129	9.983022	9.455107	10.544893	5
9.438572	9.982986	9.455586	10.544414	4
9.439014	9.982950	9.456064	10.543936	3
9.439456	9.982914	9.456542	10.543458	2
9.439897	9.982878	9.457019	10.542980	1
9.440338	9.982842	9.457496	10.542503	0

Co-sine	Sine	Co-tang	Tangent	M

Degree 74.

Degree 16.					Degree 17.				
M.	Sine	Co-sine	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.440338	9.981841	9.457498	10.542503	9.465935	9.980596	9.485339	10.514661	60
1	9.440778	9.981805	9.457973	10.542027	9.466348	9.980558	9.485791	10.514209	59
2	9.441218	9.981769	9.458449	10.541551	9.466761	9.980519	9.486242	10.513758	58
3	9.441658	9.981733	9.458925	10.541075	9.467173	9.980480	9.486693	10.513307	57
4	9.442096	9.981696	9.459400	10.540600	9.467585	9.980441	9.487143	10.512857	56
5	9.442535	9.981660	9.459875	10.540125	9.467996	9.980403	9.487593	10.512407	55
6	9.442973	9.981623	9.460349	10.539651	9.468407	9.980364	9.488043	10.511957	54
7	9.443416	9.981587	9.460819	10.539177	9.468817	9.980325	9.488493	10.511507	53
8	9.443848	9.981550	9.461297	10.538703	9.469227	9.980286	9.488941	10.511059	52
9	9.444284	9.981514	9.461770	10.538230	9.469637	9.980247	9.489390	10.510610	51
10	9.444720	9.981477	9.462242	10.537758	9.460446	9.980208	9.489838	10.510162	50
11	9.445155	9.981441	9.462714	10.537285	9.470455	9.980169	9.490286	10.509714	49
12	9.445590	9.981404	9.463186	10.536814	9.471863	9.980130	9.490733	10.509267	48
13	9.446025	9.981367	9.463658	10.536342	9.471071	9.980091	9.491180	10.508820	47
14	9.446459	9.981330	9.464129	10.535871	9.471678	9.980052	9.491627	10.508373	46
15	9.446892	9.981294	9.464599	10.535401	9.472086	9.980012	9.492073	10.507928	45
16	9.447326	9.981257	9.465069	10.534931	9.472492	9.979973	9.492519	10.507481	44
17	9.447759	9.981220	9.465539	10.534461	9.472898	9.979934	9.492964	10.507035	43
18	9.448191	9.981183	9.466008	10.533992	9.473304	9.979894	9.493410	10.506590	42
19	9.448623	9.981146	9.466476	10.533523	9.473710	9.979855	9.493854	10.506145	41
20	9.449054	9.981109	9.466945	10.533055	9.474115	9.979816	9.494299	10.505701	40
21	9.449485	9.981072	9.467413	10.532587	9.474519	9.979776	9.494743	10.505257	39
22	9.449915	9.981035	9.467880	10.532120	9.474923	9.979737	9.495186	10.504813	38
23	9.450345	9.980998	9.468347	10.531653	9.475327	9.979697	9.495630	10.504370	37
24	9.450775	9.980961	9.468814	10.531186	9.475730	9.979658	9.496073	10.503928	36
25	9.451203	9.980923	9.469280	10.530720	9.476133	9.979618	9.496515	10.503485	35
26	9.451632	9.980886	9.469746	10.530254	9.476536	9.979578	9.496957	10.503043	34
27	9.452060	9.980849	9.470211	10.529789	9.476938	9.979539	9.497399	10.502601	33
28	9.452488	9.980812	9.470676	10.529324	9.477340	9.979499	9.497840	10.502160	32
29	9.452915	9.980774	9.471141	10.528859	9.477741	9.979459	9.498282	10.501718	31
30	9.453342	9.980737	9.471605	10.528395	9.478142	9.979419	9.498722	10.501278	30
31	9.453768	9.980699	9.472068	10.527931	9.478542	9.979380	9.499163	10.500837	29
32	9.454194	9.980662	9.472532	10.527468	9.478942	9.979340	9.499602	10.500398	28
33	9.454619	9.980624	9.472995	10.527005	9.479342	9.979300	9.500042	10.499958	27
34	9.455044	9.980587	9.473457	10.526543	9.479741	9.979260	9.500481	10.499519	26
35	9.455469	9.980549	9.473919	10.526081	9.480140	9.979220	9.500920	10.499080	25
36	9.455892	9.980512	9.474381	10.525619	9.480538	9.979180	9.501359	10.498641	24
37	9.456316	9.980474	9.474842	10.525158	9.480936	9.979140	9.501797	10.498203	23
38	9.456739	9.980436	9.475303	10.524698	9.481334	9.979099	9.502234	10.497766	22
39	9.457162	9.980398	9.475762	10.524237	9.481731	9.979059	9.502672	10.497328	21
40	9.457584	9.980361	9.476223	10.523777	9.482128	9.979019	9.503109	10.496891	20
41	9.458006	9.980323	9.476683	10.523317	9.482525	9.978980	9.503546	10.496454	19
42	9.458427	9.980285	9.477142	10.522858	9.482921	9.978939	9.503982	10.496018	18
43	9.458848	9.980247	9.477601	10.522399	9.483316	9.978898	9.504418	10.495582	17
44	9.459268	9.980209	9.478059	10.521941	9.483711	9.978858	9.504854	10.495146	16
45	9.459688	9.980171	9.478517	10.521483	9.484106	9.978817	9.505289	10.494711	15
46	9.460108	9.980133	9.478975	10.521025	9.484501	9.978777	9.505724	10.494276	14
47	9.460527	9.980095	9.479432	10.520568	9.484895	9.978736	9.506158	10.493841	13
48	9.460946	9.980057	9.479889	10.520111	9.485289	9.978696	9.506593	10.493407	12
49	9.461364	9.980019	9.480345	10.519655	9.485682	9.978655	9.507026	10.492973	11
50	9.461782	9.979980	9.480801	10.519199	9.486075	9.978615	9.507459	10.492540	10
51	9.462199	9.979942	9.481257	10.518743	9.486467	9.978574	9.507892	10.492107	9
52	9.462616	9.979904	9.481712	10.518288	9.486859	9.978533	9.508326	10.491674	8
53	9.463032	9.979866	9.482167	10.517833	9.487251	9.978493	9.508759	10.491241	7
54	9.463448	9.979827	9.482621	10.517379	9.487642	9.978452	9.509181	10.490809	6
55	9.463864	9.979789	9.483074	10.516925	9.488032	9.978411	9.509622	10.490377	5
56	9.464279	9.979750	9.483528	10.516471	9.488424	9.978370	9.510054	10.489946	4
57	9.464694	9.979712	9.483981	10.516018	9.488814	9.978329	9.510486	10.489515	3
58	9.465108	9.979672	9.484434	10.515565	9.489204	9.978288	9.510916	10.489084	2
59	9.465522	9.979635	9.484887	10.515113	9.489593	9.978247	9.511346	10.488654	1
60	9.465935	9.979596	9.485339	10.514661	9.489982	9.978206	9.511776	10.488225	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang.	Tangent	M.
	Degree 73.				Degree 78				

Canon Triangulorum Logarithmicus.

Degree 18.					Degree 19.				
M.	Sine	Co-sine.	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.489981	9.978166	9.511776	10.488214	9.511642	9.975870	9.535772	10.463028	60
1	9.490371	9.978165	9.512206	10.487794	9.513009	9.975816	9.537192	10.462608	59
2	9.490759	9.978124	9.512635	10.487365	9.513375	9.975783	9.537792	10.462208	58
3	9.491147	9.978083	9.513064	10.486936	9.513741	9.975739	9.538192	10.461791	57
4	9.491534	9.978042	9.513493	10.486507	9.514107	9.975696	9.538610	10.461389	56
5	9.491922	9.978000	9.513921	10.486079	9.514472	9.975652	9.539010	10.460986	55
6	9.492308	9.977959	9.514349	10.485651	9.514837	9.975608	9.539429	10.460571	54
7	9.492695	9.977918	9.514777	10.485223	9.515202	9.975564	9.539837	10.460163	53
8	9.493080	9.977877	9.515204	10.484796	9.515566	9.975521	9.540245	10.459755	52
9	9.493466	9.977835	9.515631	10.484369	9.515930	9.975477	9.54 653	10.459347	51
10	9.493851	9.977794	9.516057	10.483942	9.516294	9.975433	9.54 061	10.458939	50
11	9.494236	9.977752	9.516484	10.483516	9.516657	9.975389	9.541468	10.458532	49
12	9.494620	9.977711	9.516910	10.483090	9.517020	9.975345	9.541875	10.458125	48
13	9.495005	9.977669	9.517333	10.482665	9.517382	9.975301	9.542281	10.457719	47
14	9.495388	9.977628	9.517761	10.482239	9.517745	9.975257	9.542688	10.457312	46
15	9.495771	9.977586	9.518185	10.481814	9.518107	9.975213	9.543094	10.456906	45
16	9.496154	9.977544	9.518610	10.481390	9.518468	9.974969	9.543499	10.456501	44
17	9.496537	9.977503	9.519034	10.480966	9.518829	9.974925	9.543905	10.456095	43
18	9.496919	9.977461	9.519458	10.480542	9.519190	9.974880	9.544310	10.455690	42
19	9.497301	9.977419	9.519881	10.480118	9.519551	9.974836	9.544715	10.455285	41
20	9.497682	9.977377	9.520305	10.489695	9.519911	9.974792	9.545110	10.454881	40
21	9.498063	9.977335	9.520728	10.479272	9.520271	9.974747	9.545524	10.454476	39
22	9.498444	9.977293	9.521151	10.478845	9.520631	9.974703	9.545927	10.454072	38
23	9.498824	9.977251	9.521573	10.478417	9.520990	9.974659	9.546331	10.453669	37
24	9.499204	9.977209	9.521995	10.478005	9.521349	9.974614	9.546735	10.453265	36
25	9.499584	9.977167	9.522417	10.477583	9.521707	9.974570	9.547138	10.452862	35
26	9.499963	9.977125	9.522838	10.477162	9.522065	9.974525	9.547540	10.452459	34
27	9.500342	9.977083	9.523259	10.476741	9.522423	9.974480	9.547943	10.452057	33
28	9.500720	9.977041	9.523679	10.476320	9.522781	9.974436	9.548345	10.451655	32
29	9.501099	9.976999	9.524109	10.475900	9.523138	9.974391	9.548747	10.451253	31
30	9.501476	9.976956	9.524520	10.475480	9.523495	9.974346	9.549149	10.450851	30
31	9.501854	9.976914	9.524939	10.475060	9.523851	9.974302	9.549550	10.450450	29
32	9.502231	9.976872	9.525359	10.474641	9.524208	9.974257	9.549951	10.450049	28
33	9.502607	9.976830	9.525778	10.474222	9.524564	9.974212	9.550352	10.449648	27
34	9.502984	9.976787	9.526197	10.473803	9.524920	9.974167	9.550752	10.449248	26
35	9.503360	9.976745	9.526615	10.473385	9.525275	9.974122	9.551152	10.448848	25
36	9.503735	9.976702	9.527033	10.472967	9.525630	9.974077	9.551552	10.448448	24
37	9.504110	9.976660	9.527451	10.472549	9.525984	9.974032	9.551952	10.448048	23
38	9.504485	9.976617	9.527868	10.472132	9.526339	9.973987	9.552351	10.447649	22
39	9.504860	9.976574	9.528285	10.471715	9.526693	9.973942	9.552750	10.447250	21
40	9.505234	9.976532	9.528702	10.471298	9.527046	9.973897	9.553149	10.446851	20
41	9.505608	9.976489	9.529118	10.470881	9.527400	9.973852	9.553548	10.446452	19
42	9.505981	9.976446	9.529535	10.470465	9.527753	9.973807	9.553946	10.446054	18
43	9.506354	9.976404	9.529950	10.470049	9.528105	9.973761	9.554344	10.445656	17
44	9.506727	9.976361	9.530366	10.469634	9.528458	9.973716	9.554741	10.445159	16
45	9.507099	9.976318	9.530781	10.469219	9.528810	9.973671	9.555139	10.444861	15
46	9.507471	9.976275	9.531196	10.468804	9.529161	9.973625	9.555536	10.444464	14
47	9.507843	9.976232	9.531611	10.468389	9.529513	9.973580	9.555932	10.444068	13
48	9.508214	9.976189	9.532025	10.467975	9.529864	9.973535	9.556329	10.443671	12
49	9.508585	9.976146	9.532436	10.467561	9.530214	9.973489	9.556725	10.443275	11
50	9.508955	9.976101	9.532852	10.467147	9.530565	9.973443	9.557121	10.442879	10
51	9.509326	9.976060	9.533266	10.466734	9.530915	9.973398	9.557517	10.442483	9
52	9.509696	9.976017	9.533679	10.466321	9.531265	9.973352	9.557912	10.442088	8
53	9.510065	9.975973	9.534092	10.465908	9.531614	9.973307	9.558308	10.441693	7
54	9.510434	9.975930	9.534504	10.465498	9.531963	9.973261	9.558702	10.441298	6
55	9.510803	9.975887	9.534916	10.465084	9.532312	9.973215	9.559097	10.440903	5
56	9.511171	9.975844	9.535328	10.464672	9.532661	9.973169	9.559492	10.440509	4
57	9.511540	9.975800	9.535739	10.464261	9.533009	9.973123	9.559885	10.440115	3
58	9.511907	9.975757	9.536150	10.463849	9.533357	9.973078	9.560279	10.439721	2
59	9.512275	9.975713	9.536561	10.463439	9.533704	9.973032	9.560673	10.439327	1
60	9.512642	9.975670	9.536972	10.463028	9.534051	9.972986	9.561066	10.438934	0
	Co-sine	Sine	Co-tang	Tangent	Co-sine	Sine	Co-tang	Tangent	M
	Degree 71.				Degree 70.				

Canon Triangulorum Logarithmicus.

Degree 20.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.534052	9.972986	9.561066	10.438934
1	9.534399	9.972940	9.561459	10.438541
2	9.534746	9.972894	9.561851	10.438148
3	9.535091	9.972848	9.562244	10.437756
4	9.535437	9.972801	9.562636	10.437364
5	9.535782	9.972755	9.563028	10.436972
6	9.536129	9.972709	9.563419	10.436580
7	9.536474	9.972663	9.563811	10.436189
8	9.536818	9.972617	9.564202	10.435798
9	9.537163	9.972570	9.564592	10.435407
10	9.537507	9.972524	9.564983	10.435017
11	9.537851	9.972477	9.565373	10.434627
12	9.538194	9.972431	9.565763	10.434237
13	9.538537	9.972384	9.566153	10.433847
14	9.538880	9.972338	9.566542	10.433457
15	9.539222	9.972291	9.566932	10.433068
16	9.539565	9.972245	9.567320	10.432679
17	9.539907	9.972198	9.567709	10.432291
18	9.540249	9.972151	9.568097	10.431902
19	9.540590	9.972105	9.568486	10.431514
20	9.540931	9.972058	9.568873	10.431126
21	9.541272	9.972011	9.569261	10.430739
22	9.541612	9.971964	9.569648	10.430351
23	9.541953	9.971917	9.560035	10.429964
24	9.542292	9.971870	9.560422	10.429578
25	9.542632	9.971823	9.560809	10.429191
26	9.542971	9.971776	9.571195	10.428805
27	9.543310	9.971729	9.571581	10.428419
28	9.543649	9.971682	9.571967	10.428033
29	9.543987	9.971635	9.572352	10.427648
30	9.544325	9.971588	9.572738	10.427262
31	9.544663	9.971540	9.573123	10.426877
32	9.545000	9.971493	9.573507	10.426492
33	9.545338	9.971446	9.573892	10.426108
34	9.545674	9.971398	9.574276	10.425724
35	9.546011	9.971351	9.574660	10.425340
36	9.546347	9.971303	9.575044	10.424956
37	9.546683	9.971256	9.575427	10.424573
38	9.547019	9.971208	9.575810	10.424189
39	9.547354	9.971161	9.576193	10.423807
40	9.547689	9.971112	9.576576	10.423424
41	9.548024	9.971065	9.576958	10.423041
42	9.548358	9.971018	9.577341	10.422659
43	9.548693	9.970970	9.577723	10.422277
44	9.549026	9.970922	9.578104	10.421896
45	9.549360	9.970874	9.578486	10.421514
46	9.549693	9.970826	9.578867	10.421133
47	9.550026	9.970779	9.579248	10.420752
48	9.550359	9.970731	9.579628	10.420371
49	9.550692	9.970683	9.580009	10.419991
50	9.551024	9.970634	9.580389	10.419611
51	9.551355	9.970586	9.580769	10.419231
52	9.551687	9.970538	9.581149	10.418851
53	9.552018	9.970490	9.581528	10.418472
54	9.552349	9.970442	9.581907	10.418092
55	9.552680	9.970394	9.582286	10.417713
56	9.553010	9.970345	9.582665	10.417335
57	9.553340	9.970297	9.583043	10.416956
58	9.553670	9.970249	9.583422	10.416578
59	9.554000	9.970200	9.583800	10.416200
60	9.554329	9.970152	9.584177	10.415823
	Co-sine	Sine	Co-tang.	Tangent

Degree 69.

Degree 21.

Sine	Co-sine	Tangent	Co-tang.	
9.554329	9.970152	9.584177	10.415822	60
9.554658	9.970103	9.584555	10.415445	59
9.554987	9.970055	9.584932	10.415068	58
9.555315	9.970006	9.585308	10.414691	57
9.555643	9.969957	9.585686	10.414314	56
9.555971	9.969909	9.586062	10.413938	55
9.556299	9.969860	9.586439	10.413561	54
9.556626	9.969811	9.586815	10.413185	53
9.556953	9.969762	9.587190	10.412800	52
9.557279	9.969713	9.587566	10.412434	51
9.557606	9.969665	9.587941	10.412059	50
9.557932	9.969616	9.588316	10.411684	49
9.558258	9.969567	9.588691	10.411309	48
9.558583	9.969518	9.589066	10.410934	47
9.558909	9.969469	9.589440	10.410560	46
9.559234	9.969419	9.589814	10.410185	45
9.559558	9.969370	9.590188	10.409812	44
9.559883	9.969321	9.590561	10.409438	43
9.560207	9.969272	9.590935	10.409065	42
9.560531	9.969223	9.591308	10.408692	41
9.560855	9.969173	9.591681	10.408319	40
9.561178	9.969124	9.592054	10.407946	39
9.561501	9.969075	9.592426	10.407574	38
9.561824	9.969025	9.592798	10.407201	37
9.562146	9.968976	9.593170	10.406829	36
9.562468	9.968926	9.593542	10.406457	35
9.562790	9.968877	9.593914	10.406086	34
9.563111	9.968827	9.594285	10.405715	33
9.563433	9.968777	9.594656	10.405344	32
9.563754	9.968728	9.595027	10.405073	31
9.564075	9.968678	9.595397	10.404601	30
9.564396	9.968628	9.595768	10.404232	29
9.564716	9.968578	9.596138	10.403861	28
9.565036	9.968528	9.596508	10.403492	27
9.565356	9.968478	9.596878	10.403122	26
9.565675	9.968428	9.597247	10.402753	25
9.565995	9.968378	9.597616	10.402384	24
9.566314	9.968328	9.597985	10.402015	23
9.566632	9.968278	9.598354	10.401646	22
9.566951	9.968228	9.598722	10.401277	21
9.567269	9.968178	9.599091	10.400909	20
9.567587	9.968128	9.599459	10.400541	19
9.567904	9.968078	9.599827	10.400173	18
9.568222	9.968027	9.690194	10.399806	17
9.568539	9.967977	9.600562	10.399438	16
9.568855	9.967927	9.600928	10.399071	15
9.569172	9.967876	9.601296	10.398704	14
9.569488	9.967826	9.601662	10.398337	13
9.569804	9.967775	9.602029	10.397971	12
9.570120	9.967725	9.602395	10.397605	11
9.570435	9.967674	9.602761	10.397239	10
9.570751	9.967623	9.603127	10.396873	9
9.571065	9.967573	9.603493	10.396507	8
9.571380	9.967522	9.603858	10.396141	7
9.571695	9.967471	9.604223	10.395777	6
9.572009	9.967420	9.604588	10.395412	5
9.572322	9.967370	9.604953	10.395047	4
9.572636	9.967319	9.605317	10.394683	3
9.572949	9.967268	9.605681	10.394318	2
9.573263	9.967217	9.606046	10.393954	1
9.573575	9.967166	9.606409	10.393590	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 68.

Canon Triangulorum Logarithmicus.

Degree 22.

M	Sine	*Co-fine.*	Tangent	*Co-tang.*
0	9.573575	9.967166	9.606409	10.393590
1	9.573885	9.967115	9.606773	10.393227
2	9.574200	9.967064	9.607136	10.392863
3	9.574512	9.967012	9.607500	10.392500
4	9.574824	9.966961	9.607862	10.392137
5	9.575135	9.966910	9.608225	10.391774
6	9.575447	9.966859	9.608588	10.391412
7	9.575758	9.966807	9.608950	10.391050
8	9.576068	9.966756	9.609312	10.390688
9	9.576379	9.966705	9.609674	10.390326
10	9.576689	9.966653	9.600036	10.389964
11	9.576999	9.966602	9.610397	10.389603
12	9.577309	9.966550	9.610758	10.389241
13	9.577618	9.966499	9.611119	10.388880
14	9.577927	9.966447	9.611480	10.388520
15	9.578236	9.966395	9.611841	10.388159
16	9.578545	9.966344	9.612201	10.387799
17	9.578853	9.966292	9.612561	10.387438
18	9.579161	9.966240	9.612921	10.387078
19	9.579469	9.966188	9.613281	10.386719
20	9.579777	9.966136	9.613641	10.386359
21	9.580084	9.966084	9.614000	10.386000
22	9.580392	9.966032	9.614359	10.385641
23	9.580698	9.965980	9.614718	10.385282
24	9.581005	9.965928	9.615077	10.384923
25	9.581311	9.965876	9.615435	10.384565
26	9.581618	9.965824	9.615793	10.384207
27	9.581923	9.965772	9.616151	10.383448
28	9.582229	9.965720	9.616509	10.383491
29	9.582534	9.965668	9.616867	10.383133
30	9.582840	9.965615	9.617224	10.382776
31	9.583144	9.965563	9.617581	10.382418
32	9.583449	9.965511	9.617938	10.382061
33	9.583753	9.965458	9.618295	10.381705
34	9.584058	9.965406	9.618652	10.381348
35	9.584361	9.965353	9.619008	10.380992
36	9.584665	9.965301	9.619364	10.380635
37	9.584968	9.965248	9.619720	10.380279
38	9.585271	9.965195	9.620076	10.379924
39	9.585574	9.965143	9.620432	10.379568
40	9.585877	9.965090	9.620787	10.379213
41	9.586179	9.965037	9.621142	10.378858
42	9.586481	9.964984	9.621497	10.378503
43	9.586783	9.964931	9.621852	10.378148
44	9.587085	9.964878	9.622206	10.377793
45	9.587386	9.964825	9.622561	10.377439
46	9.587687	9.964772	9.622915	10.377085
47	9.587988	9.964719	9.623269	10.376731
48	9.588289	9.964666	9.623623	10.376377
49	9.588589	9.964613	9.623976	10.376024
50	9.588890	9.964560	9.624330	10.375670
51	9.589190	9.964507	9.624683	10.375317
52	9.589489	9.964454	9.625036	10.374964
53	9.589789	9.964400	9.625388	10.374612
54	9.590088	9.964347	9.625741	10.374259
55	9.590387	9.964294	9.626093	10.373907
56	9.590686	9.964240	9.626445	10.373555
57	9.590984	9.964187	9.626797	10.373203
58	9.591282	9.964133	9.627149	10.372850
59	9.591580	9.964080	9.627501	10.372499
60	9.591878	9.964026	9.627852	10.372148
	Co-fine	Sine	*Co-tang.*	Tangent

Degree 67.

Degree 23.

Sine	*Co-fine*	Tangent	*Co-tang.*	
9.591878	9.964026	9.627852	10.372148	60
9.592175	9.963972	9.628203	10.371797	59
9.592473	9.963919	9.628554	10.371446	58
9.592770	9.963865	9.628905	10.371095	57
9.593067	9.963811	9.629255	10.370744	56
9.593363	9.963757	9.629606	10.370394	55
9.593659	9.963703	9.629956	10.370044	54
9.593955	9.963650	9.630306	10.369694	53
9.594251	9.963596	9.630655	10.369344	52
9.594547	9.963542	9.631005	10.368995	51
9.594842	9.963488	9.631354	10.368645	50
9.595137	9.963433	9.631704	10.368296	49
9.595432	9.963379	9.632053	10.367947	48
9.595727	9.963325	9.632401	10.367598	47
9.596021	9.963271	9.632750	10.367250	46
9.596315	9.963217	9.633098	10.366901	45
9.596610	9.963102	9.633447	10.366553	44
9.596903	9.963108	9.633795	10.366205	43
9.597196	9.963054	9.634143	10.365857	42
9.597490	9.962999	9.634490	10.365510	41
9.597783	9.962945	9.634838	10.365162	40
9.598075	9.962891	9.635185	10.364815	39
9.598368	9.962836	9.635530	10.364468	38
9.598660	9.962781	9.635879	10.364121	37
9.598952	9.962726	9.636226	10.363774	36
9.599244	9.962672	9.636572	10.363428	35
9.599536	9.962617	9.636918	10.363081	34
9.599827	9.962562	9.637205	10.362735	33
9.600118	9.962507	9.637610	10.362389	32
9.600409	9.962453	9.637956	10.362044	31
9.600700	9.962398	9.638301	10.361698	30
9.600990	9.962343	9.638647	10.361353	29
9.601280	9.962288	9.638992	10.361007	28
9.601570	9.962233	9.639337	10.360662	27
9.601860	9.962178	9.639682	10.360318	26
9.602149	9.962122	9.640027	10.359973	25
9.602439	9.962067	9.640371	10.359629	24
9.602728	9.962012	9.640716	10.359284	23
9.603017	9.961957	9.641060	10.358940	22
9.603305	9.961902	9.641404	10.358596	21
9.603594	9.961846	9.641747	10.358253	20
9.603882	9.961791	9.642091	10.357909	19
9.604170	9.961735	9.642434	10.357566	18
9.604457	9.961680	9.642777	10.357223	17
9.604745	9.961624	9.643120	10.356980	16
9.605032	9.961569	9.643463	10.356537	15
9.605319	9.961513	9.643806	10.356194	14
9.605606	9.961458	9.644148	10.355852	13
9.605892	9.961402	9.644490	10.355510	12
9.606179	9.961346	9.644832	10.355168	11
9.606465	9.961290	9.645174	10.354826	10
9.606750	9.961235	9.645516	10.354484	9
9.607036	9.961179	9.645857	10.354142	8
9.607322	9.961123	9.646199	10.353801	7
9.607607	9.961067	9.646540	10.353460	6
9.607892	9.961011	9.646881	10.353119	5
9.608176	9.960955	9.647222	10.352778	4
9.608461	9.960899	9.647562	10.352438	3
9.608745	9.960842	9.647903	10.352097	2
9.609029	9.960786	9.648243	10.351757	1
9.609313	9.960730	9.648583	10.351417	0
Co-fine	Sine	*Co-tang*	Tangent	M

Degree 66.

Canon Triangulorum Logarithmicus.

Degree 24.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.609313	9.960730	9.648583	10.351417
1	9.609597	9.960674	9.648923	10.351077
2	9.609880	9.960617	9.649263	10.350737
3	9.610163	9.960561	9.649602	10.350398
4	9.610446	9.960505	9.649942	10.350058
5	9.610729	9.960448	9.650281	10.349719
6	9.611012	9.960392	9.650620	10.349380
7	9.611294	9.960335	9.650959	10.349041
8	9.611576	9.960279	9.651297	10.348703
9	9.611858	9.960222	9.651636	10.348364
10	9.612140	9.960165	9.651974	10.348026
11	9.612421	9.960109	9.652312	10.347688
12	9.612702	9.960052	9.652650	10.347350
13	9.612983	9.959995	9.652988	10.347012
14	9.613264	9.959938	9.653326	10.346674
15	9.613545	9.959881	9.653663	10.346337
16	9.613825	9.959824	9.654000	10.345999
17	9.614105	9.959768	9.654337	10.345662
18	9.614385	9.959710	9.654674	10.345325
19	9.614665	9.959653	9.655011	10.344989
20	9.614944	9.959596	9.655348	10.344652
21	9.615223	9.959539	9.655684	10.344316
22	9.615502	9.959482	9.656020	10.343980
23	9.615781	9.959425	9.656356	10.343643
24	9.616060	9.959367	9.656692	10.343308
25	9.616338	9.959310	9.657028	10.342972
26	9.616616	9.959253	9.657363	10.342636
27	9.616894	9.959195	9.657699	10.342301
28	9.617172	9.959138	9.658034	10.341966
29	9.617450	9.959080	9.658369	10.341531
30	9.617727	9.959023	9.658704	10.341296
31	9.618004	9.958965	9.659039	10.340926
32	9.618281	9.958908	9.659373	10.340627
33	9.618558	9.958850	9.659708	10.340292
34	9.618834	9.958792	9.660042	10.339958
35	9.619110	9.958734	9.660376	10.339624
36	9.619386	9.958677	9.660710	10.339290
37	9.619662	9.958619	9.661043	10.338957
38	9.619938	9.958561	9.661377	10.338623
39	9.620213	9.958503	9.661710	10.338290
40	9.620488	9.958445	9.662043	10.337956
41	9.620763	9.958387	9.662376	10.337623
42	9.621038	9.958329	9.662709	10.337291
43	9.621313	9.958271	9.663042	10.336958
44	9.621587	9.958212	9.663374	10.336625
45	9.621861	9.958154	9.663707	10.336293
46	9.622135	9.958096	9.664039	10.335961
47	9.622409	9.958038	9.664371	10.335629
48	9.622682	9.957979	9.664703	10.335297
49	9.622956	9.957921	9.665035	10.334965
50	9.623229	9.957862	9.665366	10.334634
51	9.623501	9.957804	9.665697	10.334302
52	9.623776	9.957745	9.666029	10.333971
53	9.624047	9.957687	9.666360	10.333640
54	9.624319	9.957628	9.666691	10.333309
55	9.624591	9.957570	9.667021	10.332979
56	9.624863	9.957511	9.667352	10.332648
57	9.625134	9.957452	9.667682	10.332318
58	9.625406	9.957393	9.668012	10.331987
59	9.625677	9.957334	9.668343	10.331657
60	9.625948	9.957276	9.668672	10.331327
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 65.

Degree 25.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.625948	9.957276	9.668672	10.331327	60
9.626219	9.957217	9.669002	10.330998	59
9.626490	9.957158	9.669332	10.330668	58
9.626760	9.957099	9.669661	10.330339	57
9.627030	9.957040	9.669990	10.330009	56
9.627300	9.956981	9.670320	10.329680	55
9.627570	9.956922	9.670649	10.329351	54
9.627840	9.956862	9.670977	10.329022	53
9.628109	9.956803	9.671306	10.328694	52
9.628378	9.956744	9.671634	10.328365	51
9.628647	9.956684	9.671963	10.328037	50
9.628916	9.956625	9.672291	10.327709	49
9.629184	9.956565	9.672619	10.327381	48
9.629453	9.956506	9.672947	10.327053	47
9.629721	9.956446	9.673274	10.326725	46
9.629989	9.956387	9.673603	10.326398	45
9.630257	9.956327	9.673929	10.326070	44
9.630524	9.956267	9.674256	10.325743	43
9.630792	9.956208	9.674584	10.325416	42
9.631059	9.956148	9.674910	10.325089	41
9.631326	9.956088	9.675237	10.324763	40
9.631592	9.956029	9.675564	10.324436	39
9.631859	9.955969	9.675890	10.324110	38
9.632125	9.955909	9.676216	10.323783	37
9.632392	9.955849	9.676543	10.323457	36
9.632657	9.955789	9.676869	10.323131	35
9.632923	9.955739	9.677194	10.322805	34
9.633189	9.955669	9.677520	10.322480	33
9.633454	9.955609	9.677845	10.322154	32
9.633719	9.955548	9.678171	10.321829	31
9.633984	9.955488	9.678496	10.321504	30
9.634249	9.955428	9.678821	10.321179	29
9.634514	9.955367	9.679146	10.320854	28
9.634778	9.955307	9.679471	10.320529	27
9.635042	9.955246	9.679795	10.320205	26
9.635306	9.955186	9.680120	10.319880	25
9.635570	9.955125	9.680444	10.319556	24
9.635833	9.955065	9.680768	10.319232	23
9.636097	9.955004	9.681092	10.318908	22
9.636360	9.954944	9.681416	10.318584	21
9.636623	9.954883	9.681740	10.318260	20
9.636886	9.954823	9.682063	10.317937	19
9.637148	9.954762	9.682386	10.317613	18
9.637411	9.954701	9.682710	10.317290	17
9.637673	9.954640	9.683033	10.316967	16
9.637935	9.954579	9.683356	10.316644	15
9.638197	9.954518	9.683678	10.316321	14
9.638458	9.954457	9.684001	10.315999	13
9.638720	9.954396	9.684324	10.315676	12
9.638981	9.954335	9.684646	10.315354	11
9.639242	9.954274	9.684968	10.315032	10
9.639503	9.954213	9.685290	10.314710	9
9.639764	9.954152	9.685612	10.314388	8
9.640024	9.954090	9.685934	10.314066	7
9.640284	9.954029	9.686255	10.313745	6
9.640544	9.953968	9.686577	10.313423	5
9.640804	9.953906	9.686898	10.313102	4
9.641064	9.953845	9.687219	10.312781	3
9.641323	9.953783	9.687540	10.312460	2
9.641583	9.953721	9.687861	10.312138	1
9.641842	9.953660	9.688182	10.311818	0
Co-sine	Sine	Tangent	*Co-tang.*	M

Degree 64.

Canon Triangulorum Logarithmicus.

Degree 26.

M	Sine	Co-sine.	Tangent	Co-tang.
0	9.641842	9.953660	9.688182	10.311818
1	9.642101	9.953598	9.688502	10.311498
2	9.642360	9.953537	9.688823	10.311177
3	9.642618	9.953475	9.689143	10.310857
4	9.642876	9.953413	9.689463	10.310537
5	9.643135	9.953351	9.689783	10.310217
6	9.643393	9.953290	9.690103	10.309897
7	9.643650	9.953228	9.690423	10.309577
8	9.643908	9.953166	9.690741	10.309258
9	9.644165	9.953104	9.691063	10.308938
10	9.644423	9.953042	9.691381	10.308619
11	9.644680	9.952980	9.691700	10.308300
12	9.644936	9.952917	9.692019	10.307981
13	9.645193	9.952855	9.692338	10.307662
14	9.645449	9.952793	9.692656	10.307343
15	9.645706	9.952731	9.692975	10.307025
16	9.645962	9.952668	9.693293	10.306706
17	9.646218	9.952606	9.693612	10.306388
18	9.646473	9.952544	9.693930	10.306070
19	9.646729	9.952481	9.694248	10.305752
20	9.646984	9.952419	9.694566	10.305434
21	9.647239	9.952356	9.694883	10.305117
22	9.647494	9.952294	9.695201	10.304799
23	9.647749	9.952231	9.695518	10.304482
24	9.648004	9.952168	9.695835	10.304164
25	9.648258	9.952105	9.696153	10.303847
26	9.648512	9.952043	9.696470	10.303530
27	9.648766	9.951980	9.696786	10.303213
28	9.648020	9.951917	9.697103	10.302897
29	9.649274	9.951854	9.697420	10.302580
30	9.649527	9.951791	9.697738	10.302264
31	9.649781	9.951728	9.698052	10.301947
32	9.650034	9.951665	9.698369	10.301631
33	9.650287	9.951602	9.698685	10.301315
34	9.650519	9.951539	9.699001	10.300999
35	9.650798	9.951476	9.699316	10.300684
36	9.651044	9.951412	9.699632	10.300368
37	9.651296	9.951349	9.699947	10.300052
38	9.651648	9.951286	9.700263	10.299737
39	9.651800	9.951122	9.700578	10.299422
40	9.652052	9.951159	9.700893	10.299107
41	9.652303	9.951095	9.701208	10.298792
42	9.652555	9.951032	9.701522	10.298477
43	9.652806	9.950968	9.701837	10.298163
44	9.653057	9.950905	9.702151	10.297848
45	9.653307	9.950841	9.702466	10.297534
46	9.653558	9.950777	9.702780	10.297219
47	9.653808	9.950714	9.703095	10.296905
48	9.654059	9.950650	9.703409	10.296591
49	9.654309	9.950586	9.703721	10.296277
50	9.654558	9.950522	9.704036	10.295964
51	9.654808	9.950458	9.704350	10.295650
52	9.655057	9.950394	9.704663	10.295337
53	9.655307	9.950330	9.704976	10.295023
54	9.655556	9.950266	9.705290	10.294710
55	9.655805	9.950202	9.705603	10.294397
56	9.656053	9.950138	9.705915	10.294084
57	9.656302	9.950074	9.706228	10.293771
58	9.656550	9.950009	9.706541	10.293459
59	9.656799	9.949945	9.706853	10.293146
60	9.656347	9.949881	9.707166	10.292834
	Co-sine	Sine	Co-tang.	Tangent

Degree 63.

Degree 27.

Sine	Co-sine	Tangent	Co-tang.	
9.657047	9.949880	9.707166	10.292834	60
9.657295	9.949816	9.707478	10.292523	59
9.657542	9.949752	9.707790	10.292210	58
9.657790	9.949687	9.708102	10.291897	57
9.658037	9.949623	9.708414	10.291586	56
9.658284	9.949598	9.708726	10.291274	55
9.658531	9.949494	9.709037	10.290962	54
9.658777	9.949429	9.709349	10.290651	53
9.659024	9.949364	9.709660	10.290340	52
9.659271	9.949300	9.709971	10.290029	51
9.659517	9.949235	9.710282	10.289718	50
9.659763	9.949170	9.710593	10.289407	49
9.660009	9.949105	9.710904	10.289096	48
9.660255	9.949040	9.711214	10.288785	47
9.660500	9.948976	9.711525	10.288475	46
9.660746	9.948910	9.711836	10.288164	45
9.660991	9.948845	9.712146	10.287854	44
9.661236	9.948780	9.712456	10.287544	43
9.661481	9.948715	9.712766	10.287234	42
9.661726	9.948650	9.713076	10.286924	41
9.661970	9.948584	9.713386	10.286614	40
9.662214	9.948519	9.713695	10.286305	39
9.662459	9.948453	9.714005	10.285995	38
9.662702	9.948388	9.714314	10.285686	37
9.662947	9.948323	9.714624	10.285376	36
9.663190	9.948257	9.714933	10.285067	35
9.663433	9.948191	9.715241	10.284758	34
9.663677	9.948126	9.715550	10.284449	33
9.663920	9.948060	9.715859	10.284140	32
9.664163	9.947995	9.716168	10.283832	31
9.664406	9.947929	9.716477	10.283523	30
9.664648	9.947863	9.716785	10.283215	29
9.664891	9.947797	9.717093	10.282907	28
9.665133	9.947731	9.717401	10.282598	27
9.665375	9.947665	9.717709	10.282290	26
9.665617	9.947599	9.718017	10.281983	25
9.665858	9.947533	9.718325	10.281675	24
9.666100	9.947467	9.718633	10.281367	23
9.666341	9.947401	9.718940	10.281060	22
9.666583	9.947335	9.719248	10.280752	21
9.666824	9.947269	9.719555	10.280445	20
9.667065	9.947203	9.719862	10.280138	19
9.667305	9.947136	9.720169	10.279831	18
9.667546	9.947070	9.720476	10.279524	17
9.667786	9.947004	9.720783	10.279217	16
9.668026	9.946937	9.721089	10.278911	15
9.668266	9.946871	9.721395	10.278604	14
9.668506	9.946804	9.721702	10.278298	13
9.668746	9.946738	9.722008	10.277991	12
9.668986	9.946671	9.722315	10.277685	11
9.669225	9.946604	9.722621	10.277379	10
9.669464	9.946537	9.722927	10.277073	9
9.669703	9.946471	9.723232	10.276768	8
9.669942	9.946404	9.723538	10.276462	7
9.670181	9.946337	9.723843	10.276156	6
9.670419	9.946270	9.724149	10.275851	5
9.670657	9.946203	9.724454	10.275546	4
9.670896	9.946136	9.724759	10.275240	3
9.671134	9.946069	9.725065	10.274935	2
9.671372	9.946002	9.725369	10.274630	1
9.671609	9.945935	9.725674	10.274326	0
Co-sine	Sine	Co-tang	Tangent	M

Degree 62.

Canon Triangulorum Logarithmicus.

Degree 28.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.671609	9.945935	9.725674	10.274326
1	9.671847	9.945868	9.725979	10.274021
2	9.672084	9.945800	9.726284	10.273816
3	9.672321	9.945733	9.726588	10.273412
4	9.672558	9.945666	9.726892	10.273107
5	9.672795	9.945598	9.727197	10.272803
6	9.673032	9.945531	9.727501	10.272499
7	9.673268	9.945463	9.727805	10.272195
8	9.673505	9.945396	9.728109	10.271891
9	9.673741	9.945328	9.728412	10.271587
10	9.673977	9.945261	9.728716	10.271284
11	9.674213	9.945193	9.729020	10.270980
12	9.674448	9.945125	9.729323	10.270677
13	9.674684	9.945058	9.729626	10.270374
14	9.674919	9.944990	9.729929	10.270070
15	9.675154	9.944922	9.730232	10.269767
16	9.675389	9.944854	9.730535	10.269464
17	9.675623	9.944786	9.730838	10.269162
18	9.675859	9.944718	9.731141	10.268859
19	9.676094	9.944650	9.731443	10.268556
20	9.676328	9.944582	9.731746	10.268254
21	9.676562	9.944514	9.732048	10.267952
22	9.676796	9.944446	9.732351	10.267649
23	9.677030	9.944377	9.732653	10.267347
24	9.677264	9.944309	9.732955	10.267045
25	9.677497	9.944241	9.733257	10.266743
26	9.677731	9.944172	9.733558	10.266441
27	9.677964	9.944104	9.733860	10.266140
28	9.678197	9.944016	9.734161	10.265838
29	9.678430	9.943967	9.734463	10.265537
30	9.678663	9.943898	9.734764	10.265236
31	9.678895	9.943830	9.735066	10.264934
32	9.679128	9.943761	9.735362	10.264633
33	9.679360	9.943692	9.735668	10.264332
34	9.679592	9.943624	9.735968	10.264031
35	9.675824	9.943555	9.736169	10.263731
36	9.680056	9.943486	9.736570	10.263430
37	9.680288	9.943417	9.736870	10.263130
38	9.680519	9.943348	9.737171	10.262829
39	9.680750	9.943279	9.737471	10.262529
40	9.680982	9.943210	9.737771	10.262229
41	9.681213	9.943141	9.738071	10.261929
42	9.681443	9.943072	9.738371	10.261629
43	9.681674	9.943003	9.738671	10.261329
44	9.681904	9.942933	9.738971	10.261029
45	9.682135	9.942864	9.739271	10.260729
46	9.682365	9.942795	9.739570	10.260430
47	9.682595	9.942725	9.739870	10.260130
48	9.682825	9.942656	9.740169	10.259831
49	9.683055	9.942587	9.740468	10.259532
50	9.683284	9.942517	9.740767	10.259233
51	9.683514	9.942448	9.741066	10.258934
52	9.683743	9.942378	9.741365	10.258635
53	9.683972	9.942308	9.741664	10.258336
54	9.684201	9.942239	9.741962	10.258038
55	9.684430	9.942169	9.742261	10.257739
56	9.684658	9.942099	9.742559	10.257441
57	9.684887	9.942029	9.742858	10.257142
58	9.685115	9.941959	9.743156	10.256844
59	9.685343	9.941889	9.743454	10.256546
60	9.685571	9.941819	9.743751	10.256248
	Co-sine	Sine	Co-tang.	Tangent

Degree 61.

Degree 29.

Sine	Co-sine	Tangent	Co tang.	
9.685571	9.941819	9.743752	10.256248	60
9.685799	9.941749	9.744050	10.255950	59
9.686027	9.941679	9.744348	10.255652	58
9.686254	9.941609	9.744645	10.255355	57
9.686482	9.941535	9.744943	10.255057	56
9.686709	9.941468	9.745240	10.254760	55
9.686936	9.941398	9.745538	10.254462	54
9.687163	9.941328	9.745835	10.254165	53
9.687389	9.941257	9.746132	10.253868	52
9.687616	9.941187	9.746429	10.253571	51
9.687842	9.941116	9.746726	10.253274	50
9.688069	9.941046	9.747023	10.252977	49
9.688295	9.940975	9.747319	10.252680	48
9.688523	9.940905	9.747616	10.252384	47
9.688747	9.940834	9.747912	10.252087	46
9.688972	9.940763	9.748205	10.251791	45
9.689198	9.940693	9.748505	10.251495	44
9.689421	9.940622	9.748801	10.251199	43
9.689648	9.940551	9.749097	10.250902	42
9.689873	9.940480	9.749393	10.250607	41
9.690098	9.940409	9.749689	10.250311	40
9.690323	9.940338	9.749985	10.250015	39
9.690548	9.940267	9.750281	10.249719	38
9.690772	9.940196	9.750576	10.249424	37
9.690996	9.940125	9.750872	10.249128	36
9.691220	9.940053	9.751167	10.248833	35
9.691444	9.939982	9.751462	10.248538	34
9.691668	9.939911	9.751757	10.248243	33
9.691892	9.939840	9.752052	10.247948	32
9.692115	9.939768	9.752347	10.247653	31
9.692339	9.939697	9.752641	10.247358	30
9.692562	9.939625	9.752937	10.247063	29
9.692785	9.939554	9.753231	10.246769	28
9.693008	9.939482	9.753526	10.246474	27
9.693231	9.939410	9.753820	10.246180	26
9.693453	9.939339	9.754115	10.245885	25
9.693676	9.939267	9.754409	10.245591	24
9.693898	9.939195	9.754703	10.245297	23
9.694120	9.939123	9.754997	10.245003	22
9.694342	9.939051	9.755291	10.244709	21
9.694564	9.938980	9.755584	10.244415	20
9.694786	9.938908	9.755878	10.244122	19
9.695007	9.938835	9.756172	10.243828	18
9.695229	9.938763	9.756465	10.243535	17
9.695450	9.938691	9.756759	10.243241	16
9.695671	9.938619	9.757052	10.242948	15
9.695892	9.938547	9.757345	10.242655	14
9.696113	9.938475	9.757638	10.242362	13
9.696334	9.938402	9.757931	10.242069	12
9.696554	9.938330	9.758224	10.241776	11
9.696774	9.938257	9.758517	10.241483	10
9.696995	9.938185	9.758810	10.241190	9
9.697215	9.938112	9.759102	10.240898	8
9.697435	9.938040	9.759395	10.240605	7
9.697654	9.937967	9.759687	10.240313	6
9.697874	9.937895	9.759979	10.240021	5
9.698093	9.937822	9.760271	10.239728	4
9.698313	9.937749	9.760564	10.239436	3
9.698532	9.937676	9.760856	10.239144	2
9.698751	9.937603	9.761147	10.238852	1
9.698970	9.937531	9.761439	10.238561	0
Co-sine	Sine	Co tang	Tangent	M

Degree 60.

Canon Triangulorum Logarithmicus.

Degree 30.					Degree 31.				
M	Sine	*Co-sine*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.698970	9.937531	9.761439	10.238561	9.711839	9.933066	9.778774	10.221226	60
1	9.699189	9.937458	9.761731	10.238269	9.712045	9.932990	9.779060	10.220940	59
2	9.699407	9.937385	9.762023	10.237977	9.712259	9.932914	9.779346	10.220654	58
3	9.699626	9.937312	9.762314	10.237686	9.712469	9.932838	9.779632	10.220368	57
4	9.699844	9.937238	9.762606	10.237394	9.712679	9.932761	9.779918	10.220082	56
5	9.700062	9.937165	9.762897	10.237103	9.712889	9.932685	9.780203	10.219796	55
6	9.700280	9.937092	9.763188	10.236812	9.713098	9.932609	9.780489	10.219511	54
7	9.700498	9.937019	9.763479	10.236521	9.713308	9.932533	9.780775	10.219225	53
8	9.700716	9.936945	9.763770	10.236230	9.713517	9.932457	9.781060	10.218940	52
9	9.700933	9.936872	9.764061	10.235939	9.713726	9.932380	9.781346	10.218654	51
10	9.701151	9.936799	9.764352	10.235648	9.713935	9.932304	9.781631	10.218369	50
11	9.701568	9.936725	9.764643	10.235357	9.714144	9.932227	9.781916	10.218084	49
12	9.701585	9.936652	9.764933	10.235067	9.714352	9.932151	9.782202	10.217799	48
13	9.701802	9.936578	9.765224	10.234776	9.714561	9.932074	9.782486	10.217514	47
14	9.702019	9.936505	9.765514	10.234486	9.714769	9.931998	9.782771	10.217229	46
15	9.702236	9.936431	9.765805	10.234195	9.714977	9.931921	9.783056	10.216944	45
16	9.702452	9.936357	9.766095	10.233905	9.715186	9.931845	9.783341	10.216659	44
17	9.702669	9.936284	9.766385	10.233615	9.715394	9.931768	9.783626	10.216374	43
18	9.702885	9.936210	9.766675	10.233325	9.715601	9.931691	9.783910	10.216090	42
19	9.703101	9.936136	9.766965	10.233035	9.715809	9.931614	9.784195	10.215805	41
20	9.703317	9.936062	9.767255	10.232745	9.716017	9.931537	9.784479	10.215520	40
21	9.703533	9.935988	9.767545	10.232455	9.716224	9.931460	9.784764	10.215236	39
22	9.703748	9.935914	9.767834	10.232166	9.716431	9.931383	9.785048	10.214952	38
23	9.703964	9.935840	9.768124	10.231876	9.716639	9.931306	9.785332	10.214668	37
24	9.704179	9.935766	9.768413	10.231587	9.716846	9.931229	9.785616	10.214384	36
25	9.704395	9.935692	9.768703	10.231297	9.717053	9.931152	9.785900	10.214099	35
26	9.704610	9.935618	9.768992	10.231008	9.717259	9.931075	9.786184	10.213816	34
27	9.704825	9.935543	9.769281	10.230719	9.717466	9.930998	9.786468	10.213532	33
28	9.705040	9.935469	9.769570	10.230430	9.717672	9.930920	9.786752	10.213248	32
29	9.705254	9.935395	9.769859	10.230141	9.717879	9.930843	9.787036	10.212964	31
30	9.705469	9.935320	9.770148	10.229852	9.718085	9.930766	9.787319	10.212681	30
31	9.705683	9.935246	9.770437	10.229563	9.718291	9.930688	9.787603	10.212397	29
32	9.705897	9.935171	9.770726	10.229274	9.718497	9.930611	9.787886	10.212114	28
33	9.706112	9.935097	9.771015	10.228985	9.718703	9.930533	9.788170	10.211830	27
34	9.706326	9.935022	9.771303	10.228697	9.718909	9.930456	9.788453	10.211547	26
35	9.706539	9.934948	9.771592	10.228408	9.719114	9.930378	9.788736	10.211264	25
36	9.706753	9.934873	9.771880	10.228120	9.719320	9.930300	9.789019	10.210981	24
37	9.706967	9.934798	9.772168	10.227832	9.719525	9.930223	9.789302	10.210698	23
38	9.707180	9.934723	9.772456	10.227543	9.719730	9.930145	9.789585	10.210415	22
39	9.707393	9.934649	9.772745	10.227255	9.719935	9.930067	9.789868	10.210132	21
40	9.707606	9.934574	9.773033	10.226967	9.720140	9.929989	9.790151	10.209849	20
41	9.707819	9.934499	9.773321	10.226679	9.720345	9.929911	9.790433	10.209566	19
42	9.708032	9.934424	9.773608	10.226391	9.720549	9.929833	9.790716	10.209284	18
43	9.708245	9.934349	9.773896	10.226104	9.720754	9.929755	9.790999	10.209001	17
44	9.708457	9.934274	9.774184	10.225816	9.720958	9.929677	9.791281	10.208719	16
45	9.708670	9.934199	9.774471	10.225529	9.721161	9.929595	9.791563	10.208436	15
46	9.708882	9.934123	9.774759	10.225241	9.721366	9.929521	9.791846	10.208154	14
47	9.709094	9.934048	9.775046	10.224954	9.721570	9.929442	9.792128	10.207872	13
48	9.709306	9.933973	9.775333	10.224666	9.721774	9.929364	9.792410	10.207590	12
49	9.709518	9.933897	9.775621	10.224379	9.721978	9.929286	9.792692	10.207308	11
50	9.709730	9.933821	9.775908	10.224091	9.722181	9.929207	9.792974	10.207024	10
51	9.709941	9.933747	9.776195	10.223805	9.722385	9.929129	9.793256	10.206744	9
52	9.710153	9.933671	9.776482	10.223518	9.722588	9.929050	9.793538	10.206462	8
53	9.710364	9.933596	9.776768	10.223232	9.722791	9.928972	9.793819	10.206180	7
54	9.710575	9.933520	9.777055	10.222945	9.722994	9.928893	9.794101	10.205899	6
55	9.710786	9.933444	9.777342	10.222658	9.723197	9.928814	9.794383	10.205617	5
56	9.710997	9.933369	9.777628	10.222372	9.723400	9.928736	9.794664	10.205336	4
57	9.711208	9.933293	9.777915	10.222085	9.723603	9.928657	9.794945	10.205054	3
58	9.711418	9.933217	9.778201	10.221799	9.723805	9.928578	9.795227	10.204773	2
59	9.711629	9.933141	9.778487	10.221513	9.724007	9.928499	9.795508	10.204492	1
60	9.711839	9.933066	9.778774	10.221226	9.724210	9.928420	9.795789	10.204211	0
	Co-sine	Sine	*Co-tang.*	Tangent	*Co-sine*	Sine	*Co-tang.*	Tangent	M
	Degree 59.				Degree 58.				

Canon Triangulorum Logarithmicus.

Degree 32.				
M	Sine	Co-sine	Tangent	Co-tang.
0	9.724210	9.928420	9.795789	10.204211
1	9.724412	9.928341	9.796070	10.203930
2	9.724614	9.928262	9.796351	10.203649
3	9.724816	9.928183	9.796632	10.203368
4	9.725017	9.928104	9.796913	10.203087
5	9.725219	9.928025	9.797194	10.202806
6	9.725420	9.927946	9.797474	10.202522
7	9.725622	9.927867	9.797755	10.202245
8	9.725823	9.927787	9.798036	10.201964
9	9.726024	9.927708	9.798316	10.201684
10	9.726225	9.927628	9.798596	10.201404
11	9.726426	9.927549	9.798877	10.201123
12	9.726626	9.927469	9.799157	10.200843
13	9.726827	9.927390	9.799437	10.200563
14	9.727027	9.927310	9.799717	10.200283
15	9.727228	9.927231	9.799997	10.200003
16	9.727428	9.927151	9.800277	10.199723
17	9.727628	9.927071	9.800557	10.199443
18	9.727828	9.926991	9.800836	10.199163
19	9.728027	9.926911	9.801116	10.198884
20	9.728227	9.926831	9.801396	10.198604
21	9.728427	9.926751	9.801675	10.198325
22	9.728626	9.926671	9.801955	10.198045
23	9.728825	9.926591	9.802234	10.197766
24	9.729024	9.926511	9.802513	10.197487
25	9.729223	9.926431	9.802791	10.197207
26	9.729422	9.926351	9.803072	10.196928
27	9.729621	9.926270	9.803351	10.196649
28	9.729820	9.926190	9.803630	10.196370
29	9.730018	9.926110	9.803908	10.196091
30	9.730216	9.926029	9.804187	10.195813
31	9.730415	9.925949	9.804466	10.195534
32	9.730613	9.925868	9.804745	10.195255
33	9.730811	9.925787	9.805023	10.194977
34	9.731009	9.925707	9.805302	10.194698
35	9.731206	9.925626	9.805580	10.194420
36	9.731404	9.925545	9.805859	10.194141
37	9.731601	9.925464	9.806137	10.193863
38	9.731799	9.925384	9.806415	10.193585
39	9.731996	9.925303	9.806693	10.193309
40	9.732193	9.925222	9.806971	10.193028
41	9.732390	9.925141	9.807249	10.192751
42	9.732587	9.925060	9.807527	10.192433
43	9.732784	9.924978	9.807805	10.192195
44	9.732980	9.924897	9.808083	10.191917
45	9.733177	9.924816	9.808361	10.191639
46	9.733373	9.924735	9.808638	10.191362
47	9.733569	9.924653	9.808916	10.191084
48	9.733765	9.924572	9.809193	10.190807
49	9.733961	9.924491	9.809471	10.190529
50	9.734157	9.924409	9.809748	10.190252
51	9.734353	9.924328	9.810025	10.189975
52	9.734548	9.924246	9.810302	10.189697
53	9.734744	9.924164	9.810580	10.189420
54	9.734939	9.924083	9.810857	10.189143
55	9.735134	9.924001	9.811134	10.188866
56	9.735330	9.923919	9.811410	10.188589
57	9.735525	9.923837	9.811687	10.188313
58	9.735719	9.923755	9.811964	10.188036
59	9.735914	9.923673	9.812241	10.187759
60	9.736109	9.923591	9.812517	10.187483
	Co sine	Sine	Co-tang.	Tangent

Degree 57.

Degree 33.				
Sine	Co-sine	Tangent	Co-tang.	
9.736109	9.923591	9.812517	10.187483	60
9.736309	9.923509	9.812794	10.187206	59
9.736497	9.923427	9.813070	10.186930	58
9.736692	9.923345	9.813347	10.186653	57
9.736886	9.923263	9.813623	10.186377	56
9.737080	9.923180	9.813899	10.186101	55
9.737274	9.923098	9.814175	10.185824	54
9.737467	9.923016	9.814452	10.185548	53
9.737661	9.922933	9.814728	10.185272	52
9.737854	9.922851	9.815004	10.184996	51
9.738048	9.922768	9.815279	10.184720	50
9.738241	9.922686	9.815555	10.184445	49
9.738434	9.922603	9.815831	10.184169	48
9.738627	9.922520	9.816107	10.183893	47
9.738820	9.922438	9.816382	10.183617	46
9.739013	9.922355	9.816658	10.183342	45
9.739205	9.922272	9.816933	10.183066	44
9.739398	9.922189	9.817209	10.182791	43
9.739590	9.922106	9.817484	10.182516	42
9.739783	9.922023	9.817759	10.182240	41
9.739975	9.921940	9.818035	10.181965	40
9.740167	9.921857	9.818310	10.181690	39
9.740359	9.921774	9.818585	10.181415	38
9.740550	9.921691	9.818860	10.181140	37
9.740742	9.921607	9.819135	10.180865	36
9.740934	9.921524	9.819410	10.180590	35
9.741125	9.921441	9.819684	10.180315	34
9.741316	9.921357	9.819959	10.180041	33
9.741507	9.921274	9.820234	10.179766	32
9.741698	9.921190	9.820508	10.179492	31
9.741889	9.921107	9.820783	10.179217	30
9.742080	9.921023	9.821057	10.178943	29
9.742271	9.920939	9.821332	10.178668	28
9.742461	9.920855	9.821606	10.178394	27
9.742652	9.920772	9.821880	10.178120	26
9.742842	9.920688	9.822154	10.177846	25
9.743032	9.920604	9.822429	10.177571	24
9.743223	9.920520	9.822703	10.177297	23
9.743412	9.920436	9.822977	10.177023	22
9.743601	9.920352	9.823250	10.176749	21
9.743791	9.920268	9.823524	10.176476	20
9.743982	9.920184	9.823798	10.176202	19
9.744171	9.920099	9.824072	10.175928	18
9.744361	9.920015	9.824345	10.175655	17
9.744550	9.919931	9.824619	10.175381	16
9.744739	9.919846	9.824891	10.175108	15
9.744928	9.919762	9.825166	10.174834	14
9.745117	9.919677	9.825439	10.174560	13
9.745306	9.919593	9.825713	10.174287	12
9.745494	9.919508	9.825986	10.174014	11
9.745683	9.919424	9.826259	10.173741	10
9.745871	9.919339	9.826532	10.173498	9
9.746059	9.919254	9.826805	10.173195	8
9.746248	9.919169	9.827078	10.172922	7
9.746436	9.919084	9.827351	10.172649	6
9.746624	9.918999	9.827624	10.172376	5
9.746811	9.918915	9.827897	10.172103	4
9.746999	9.918830	9.828170	10.171830	3
9.747187	9.918744	9.828442	10.171558	2
9.747374	9.918659	9.828715	10.171285	1
9.747562	9.918574	9.828987	10.171012	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 56.

Canon Triangulorum Logarithmicus.

Degree 34.					Degree 35.				
M	Sine	Co-sine.	Tangent	Co-tang.	Sine	Co-sine	Tangent	Co-tang.	
0	9.747562	9.918574	9.828987	10.171012	9.758591	9.913364	9.845227	10.154774	60
1	9.747749	9.918489	9.829260	10.170740	9.758772	9.913276	9.845496	10.154504	59
2	9.747936	9.918404	9.829532	10.170468	9.758952	9.913187	9.845764	10.154235	58
3	9.748123	9.918318	9.829805	10.170195	9.759132	9.913099	9.846033	10.153967	57
4	9.748310	9.918233	9.830077	10.169923	9.759312	9.913010	9.846302	10.153698	56
5	9.748497	9.918147	9.830349	10.169651	9.759492	9.912921	9.846570	10.153429	55
6	9.748683	9.918062	9.830621	10.169379	9.759672	9.912833	9.846839	10.153161	54
7	9.748870	9.917976	9.830893	10.169106	9.759851	9.912744	9.847107	10.152892	53
8	9.749056	9.917891	9.831165	10.168834	9.760031	9.912655	9.847376	10.152624	52
9	9.749242	9.917805	9.831437	10.168563	9.760210	9.912566	9.847644	10.152356	51
10	9.749429	9.917719	9.831705	10.168291	9.760390	9.912477	9.847913	10.152087	50
11	9.749615	9.917634	9.831981	10.168019	9.760569	9.912388	9.848181	10.151819	49
12	9.749801	9.917548	9.832253	10.167747	9.760748	9.912299	9.848449	10.151551	48
13	9.749986	9.917462	9.832525	10.167475	9.760927	9.912210	9.848717	10.151283	47
14	9.750172	9.917376	9.832796	10.167204	9.761106	9.912121	9.848985	10.151015	46
15	9.750358	9.917290	9.833068	10.166932	9.761285	9.912031	9.849254	10.150746	45
16	9.750543	9.917204	9.833339	10.166660	9.761464	9.911942	9.849522	10.150478	44
17	9.750729	9.917118	9.833611	10.166389	9.761642	9.911853	9.849789	10.150214	43
18	9.750914	9.917032	9.833882	10.166118	9.761821	9.911763	9.850057	10.149943	42
19	9.751099	9.916945	9.834154	10.165846	9.761999	9.911674	9.850325	10.149675	41
20	9.751284	9.916859	9.834425	10.165575	9.762177	9.911584	9.850593	10.149407	40
21	9.751469	9.916773	9.834696	10.165304	9.762356	9.911495	9.850861	10.149139	39
22	9.751654	9.916686	9.834967	10.165033	9.762534	9.911405	9.851128	10.148872	38
23	9.751838	9.916600	9.835238	10.164762	9.762712	9.911315	9.851396	10.148604	37
24	9.752023	9.916514	9.835509	10.164491	9.762889	9.911226	9.851664	10.148336	36
25	9.752207	9.916427	9.835780	10.164220	9.763067	9.911136	9.851931	10.148069	35
26	9.752392	9.916340	9.836051	10.163949	9.763245	9.911046	9.852199	10.147801	34
27	9.752576	9.916254	9.836322	10.163678	9.763422	9.910956	9.852466	10.147534	33
28	9.752760	9.916167	9.836593	10.163407	9.763599	9.910866	9.852732	10.147267	32
29	9.752944	9.916080	9.836864	10.163136	9.763777	9.910776	9.853001	10.146999	31
30	9.753128	9.915994	9.837134	10.162866	9.763954	9.910686	9.853268	10.146732	30
31	9.753312	9.915907	9.837405	10.162595	9.764131	9.910596	9.853532	10.146465	29
32	9.753495	9.915820	9.837675	10.162325	9.764308	9.910506	9.853802	10.146198	28
33	9.753679	9.915733	9.837946	10.162054	9.764485	9.910415	9.854069	10.145930	27
34	9.753862	9.915646	9.838216	10.161784	9.764662	9.910325	9.854336	10.145664	26
35	9.754046	9.915559	9.838487	10.161513	9.764838	9.910235	9.854603	10.145397	25
36	9.754229	9.915472	9.838757	10.161243	9.765015	9.910144	9.854870	10.145130	24
37	9.754412	9.915385	9.839027	10.160973	9.765191	9.910054	9.855137	10.144863	23
38	9.754595	9.915297	9.839297	10.160702	9.765367	9.909963	9.855404	10.144596	22
39	9.754778	9.915210	9.839568	10.160432	9.765544	9.909873	9.855671	10.144329	21
40	9.754960	9.915123	9.839838	10.160162	9.765720	9.909782	9.855937	10.144063	20
41	9.755143	9.915035	9.840108	10.159892	9.765896	9.909691	9.856204	10.143796	19
42	9.755325	9.914948	9.840378	10.159622	9.766071	9.909601	9.856471	10.143529	18
43	9.755508	9.914860	9.840647	10.159352	9.766247	9.909510	9.856737	10.143263	17
44	9.755690	9.914773	9.840917	10.159083	9.766423	9.909419	9.857004	10.142996	16
45	9.755872	9.914685	9.841187	10.158813	9.766598	9.909328	9.857270	10.142730	15
46	9.756054	9.914597	9.841457	10.158543	9.766774	9.909237	9.857537	10.142463	14
47	9.756236	9.914510	9.841726	10.158273	9.766949	9.909146	9.857803	10.142197	13
48	9.756418	9.914422	9.841996	10.158004	9.767124	9.909055	9.858069	10.141931	12
49	9.756600	9.914334	9.842266	10.157734	9.767299	9.908964	9.858336	10.141664	11
50	9.756781	9.914246	9.842535	10.157465	9.767474	9.908873	9.858602	10.141398	10
51	9.756963	9.914158	9.842804	10.157195	9.767649	9.908781	9.858868	10.141132	9
52	9.757144	9.914070	9.843074	10.156926	9.767824	9.908690	9.859134	10.140866	8
53	9.757326	9.913982	9.843343	10.156657	9.767997	9.908599	9.859400	10.140600	7
54	9.757507	9.913894	9.843612	10.156387	9.768173	9.908507	9.859666	10.140334	6
55	9.757688	9.913806	9.843882	10.156118	9.768348	9.908416	9.859932	10.140068	5
56	9.757869	9.913718	9.844151	10.155849	9.768522	9.908324	9.860198	10.139802	4
57	9.758049	9.913630	9.844420	10.155580	9.768696	9.908233	9.860464	10.139536	3
58	9.758230	9.913541	9.844689	10.155311	9.768871	9.908141	9.860730	10.139270	2
59	9.758411	9.913453	9.844958	10.155042	9.769045	9.908049	9.860995	10.139005	1
60	9.758591	9.913364	9.845227	10.154774	9.769219	9.907958	9.861261	10.138739	0
	Co-sine	Sine	Co-tang.	Tangent	Co-sine	Sine	Co-tang	Tangent	M
	Degree 55.				Degree 54.				

Canon Triangulorum Logarithmicus.

Degree 36.					Degree 37.				
M	Sine	*Co-fine.*	Tangent	*Co-tang.*	Sine	*Co-fine*	Tangent	*Co-tang.*	
0	9.769219	9.907958	9.861261	10.138739	9.779463	9.902349	9.877114	10.122885	60
1	9.769392	9.907866	9.861527	10.138473	9.779631	9.902253	9.877377	10.122623	59
2	9.769566	9.907774	9.861792	10.138208	9.779798	9.902158	9.877640	10.122360	58
3	9.769740	9.907682	9.862058	10.137942	9.779965	9.902063	9.877903	10.122097	57
4	9.769913	9.907590	9.862323	10.137677	9.780133	9.901967	9.878165	10.121834	56
5	9.770087	9.907498	9.862589	10.137411	9.780300	9.901872	9.878428	10.121572	55
6	9.770260	9.907406	9.862854	10.137146	9.780467	9.901776	9.878691	10.121309	54
7	9.770433	9.907314	9.863119	10.136880	9.780634	9.901681	9.878953	10.121047	53
8	9.770606	9.907221	9.863385	10.136615	9.780801	9.901585	9.879216	10.120784	52
9	9.770779	9.907129	9.863650	10.136350	9.780968	9.901488	9.879478	10.120522	51
10	9.770952	9.907037	9.863915	10.136085	9.781134	9.901391	9.879741	10.120259	50
11	9.771125	9.906945	9.864180	10.135820	9.781301	9.901298	9.880003	10.119997	49
12	9.771298	9.906852	9.864445	10.135554	9.781467	9.901202	9.880265	10.119734	48
13	9.771470	9.906760	9.864710	10.135289	9.781634	9.901106	9.880528	10.119472	47
14	9.771643	9.906667	9.864975	10.135024	9.781800	9.901010	9.880790	10.119210	46
15	9.771815	9.906574	9.865240	10.134759	9.781966	9.900914	9.881052	10.118948	45
16	9.771987	9.906481	9.865505	10.134495	9.782132	9.900818	9.881314	10.118686	44
17	9.772159	9.906389	9.865770	10.134230	9.782298	9.900722	9.881576	10.118424	43
18	9.772331	9.906296	9.866035	10.133965	9.782464	9.900626	9.881839	10.118161	42
19	9.772503	9.906203	9.866300	10.133700	9.782630	9.900529	9.882101	10.117899	41
20	9.772675	9.906111	9.866564	10.133436	9.782796	9.900433	9.882363	10.117637	40
21	9.772847	9.906018	9.866829	10.133171	9.782961	9.900337	9.882625	10.117375	39
22	9.773018	9.905925	9.867094	10.132906	9.783127	9.900240	9.882886	10.117114	38
23	9.773190	9.905832	9.867358	10.132642	9.783292	9.900144	9.883148	10.116852	37
24	9.773361	9.905738	9.867623	10.132377	9.783457	9.900047	9.883410	10.116590	36
25	9.773533	9.905645	9.867887	10.132113	9.783623	9.899951	9.883672	10.116328	35
26	9.773704	9.905552	9.868152	10.131848	9.783788	9.899854	9.883934	10.116066	34
27	9.773875	9.905459	9.868416	10.131584	9.783953	9.899757	9.884195	10.115805	33
28	9.774046	9.905365	9.868680	10.131320	9.784118	9.899660	9.884457	10.115543	32
29	9.774217	9.905272	9.868945	10.131055	9.784282	9.899563	9.884719	10.115281	31
30	9.774388	9.905179	9.869209	10.130791	9.784447	9.899467	9.884980	10.115020	30
31	9.774558	9.905085	9.864773	10.130527	9.784616	9.899370	9.885242	10.114758	29
32	9.774729	9.904992	9.867337	10.130263	9.784776	9.899273	9.885503	10.114497	28
33	9.774899	9.904898	9.870001	10.129999	9.784941	9.899175	9.885765	10.114235	27
34	9.775070	9.904804	9.870265	10.129735	9.785105	9.899078	9.886026	10.113974	26
35	9.775240	9.904711	9.870529	10.129471	9.785269	9.898981	9.886288	10.113712	25
36	9.775410	9.904617	9.870793	10.129207	9.785433	9.898884	9.886549	10.113451	24
37	9.775580	9.904523	9.871057	10.128943	9.785591	9.898787	9.886810	10.113190	23
38	9.775750	9.904429	9.871321	10.128679	9.785761	9.898689	9.887072	10.112928	22
39	9.775920	9.904335	9.871585	10.128415	9.785925	9.898592	9.887333	10.112667	21
40	9.776090	9.904241	9.871849	10.128151	9.786088	9.898494	9.887594	10.112406	20
41	9.776259	9.904147	9.872112	10.127888	9.786252	9.898397	9.887855	10.112145	19
42	9.776429	9.904053	9.872376	10.127624	9.786416	9.898299	9.888116	10.111884	18
43	9.776598	9.903959	9.872640	10.127360	9.786579	9.898201	9.888377	10.111623	17
44	9.776768	9.903864	9.872903	10.127097	9.786741	9.898104	9.888638	10.111361	16
45	9.776937	9.903770	9.873167	10.126833	9.786909	9.898006	9.888899	10.111101	15
46	9.777106	9.903676	9.873430	10.126570	9.787069	9.897908	9.889160	10.110840	14
47	9.777275	9.903581	9.873694	10.126306	9.787232	9.897810	9.889421	10.110579	13
48	9.777444	9.903486	9.873957	10.126043	9.787395	9.897112	9.889682	10.110318	12
49	9.777613	9.903392	9.874220	10.125780	9.787557	9.897614	9.889943	10.110057	11
50	9.777781	9.903298	9.874484	10.125516	9.787720	9.897516	9.890204	10.109796	10
51	9.777950	9.903203	9.874747	10.125253	9.787883	9.897418	9.890465	10.109535	9
52	9.778119	9.903108	9.875010	10.124990	9.788045	9.897320	9.890725	10.109275	8
53	9.778287	9.903013	9.875273	10.124727	9.788208	9.897222	9.890986	10.109014	7
54	9.778455	9.902919	9.875536	10.124464	9.788370	9.897123	9.891247	10.108753	6
55	9.778623	9.902824	9.875799	10.124201	9.788532	9.897025	9.891507	10.108493	5
56	9.778792	9.902729	9.876063	10.123937	9.788694	9.896926	9.891768	10.108232	4
57	9.778960	9.902634	9.876326	10.123674	9.788856	9.896828	9.892028	10.107972	3
58	9.779129	9.902539	9.876589	10.123411	9.789018	9.896729	9.892289	10.107711	2
59	9.779295	9.902444	9.876851	10.123149	9.789180	9.896631	9.892549	10.107451	1
60	9.779463	9.902349	9.877114	10.122886	9.789342	9.896532	9.892810	10.107190	0
	Co-fine	Sine	*Co-tang.*	Tangent	*Co-fine*	Sine	*Co-tang*	Tangent	M
	Degree 53.				Degree 52.				

Canon Triangulorum Logarithmicus.

Degree 38.

M	Sine	*Co-fine.*	Tangent	*Co-tang.*
0	9.789342	9.896532	9.892810	10.107190
1	9.789504	9.896433	9.893070	10.106930
2	9.789665	9.896335	9.893330	10.106669
3	9.789827	9.896236	9.893591	10.106409
4	9.789988	9.896137	9.893851	10.106149
5	9.792149	9.896038	9.894111	10.105889
6	9.790310	9.895939	9.894371	10.105628
7	9.790471	9.895840	9.894632	10.105368
8	9.790632	9.895741	9.894892	10.105108
9	9.790793	9.895641	9.895152	10.104848
10	9.790954	9.895542	9.895412	10.104588
11	9.791115	9.895443	9.895672	10.104328
12	9.791275	9.895343	9.895932	10.104068
13	9.791436	9.895244	9.896192	10.103808
14	9.791596	9.895144	9.896452	10.103548
15	9.791756	9.895045	9.896712	10.103288
16	9.791917	9.894945	9.896971	10.103028
17	9.792077	9.894846	9.897231	10.102769
18	9.792237	9.894746	9.897491	10.102509
19	9.792397	9.894646	9.897751	10.102249
20	9.792557	9.894546	9.898010	10.101990
21	9.792716	9.894446	9.898270	10.101730
22	9.792876	9.894346	9.898530	10.101470
23	9.793035	9.894246	9.898789	10.101211
24	9.793195	9.894146	9.899049	10.100951
25	9.793354	9.894046	9.899308	10.100691
26	9.793513	9.893946	9.899568	10.100431
27	9.793673	9.893845	9.899827	10.100173
28	9.793832	9.893745	9.900086	10.099913
29	9.793991	9.893645	9.900346	10.099654
30	9.794149	9.893544	9.900605	10.099395
31	9.794308	9.893444	9.900864	10.099135
32	9.794467	9.893343	9.901124	10.098876
33	9.794626	9.893243	9.901383	10.098617
34	9.794784	9.893142	9.901642	10.098358
35	9.794941	9.893041	9.901901	10.098099
36	9.795101	9.892940	9.902160	10.097839
37	9.795259	9.892839	9.902419	10.097580
38	9.795417	9.892738	9.902678	10.097321
39	9.795575	9.892637	9.902937	10.097062
40	9.795733	9.892536	9.903196	10.096803
41	9.795891	9.892435	9.903455	10.096544
42	9.796049	9.892334	9.903714	10.096285
43	9.796206	9.892233	9.903973	10.096027
44	9.796364	9.892132	9.904232	10.095768
45	9.796521	9.892030	9.904491	10.095509
46	9.796678	9.891929	9.904750	10.095250
47	9.796836	9.891827	9.905008	10.094991
48	9.796993	9.891726	9.905267	10.094733
49	9.797150	9.891624	9.905526	10.094474
50	9.797307	9.891522	9.905784	10.094215
51	9.797464	9.891421	9.906043	10.093957
52	9.797621	9.891319	9.906302	10.093698
53	9.797777	9.891217	9.906560	10.093440
54	9.797934	9.891115	9.906819	10.093181
55	9.798091	9.891013	9.907077	10.092923
56	9.798247	9.890911	9.907336	10.092664
57	9.798403	9.890809	9.907594	10.092406
58	9.798560	9.890707	9.907852	10.092147
59	9.798716	9.890605	9.908111	10.091889
60	9.798872	9.890503	9.908369	10.091631
	Co-fine	Sine	*Co-tang.*	Tangent

Degree 51.

Degree 39.

Sine	*Co-fine*	Tangent	*Co-tang.*	
9.798872	9.890503	9.908369	10.091631	60
9.799028	9.890400	9.908627	10.091373	59
9.799184	9.890296	9.908886	10.091114	58
9.799339	9.890195	9.909144	10.090856	57
9.799495	9.890093	9.909402	10.090598	56
9.799651	9.889990	9.909660	10.090340	55
9.799806	9.889888	9.909918	10.090081	54
9.799961	9.889785	9.910176	10.089823	53
9.800117	9.889682	9.910435	10.089565	52
9.800272	9.889579	9.910693	10.089307	51
9.800427	9.889476	9.910951	10.089049	50
9.800582	9.889374	9.911209	10.088791	49
9.800737	9.889271	9.911467	10.088533	48
9.800892	9.889167	9.911724	10.088275	47
9.801047	9.889064	9.911982	10.088017	46
9.801201	9.888961	9.912240	10.087760	45
9.801356	9.888858	9.912498	10.087502	44
9.801510	9.888755	9.912756	10.087244	43
9.801665	9.888651	9.913014	10.086986	42
9.801819	9.888548	9.913271	10.086729	41
9.801973	9.888444	9.913529	10.086471	40
9.802127	9.888341	9.913787	10.086213	39
9.802281	9.888237	9.914044	10.085956	38
9.802435	9.888133	9.914302	10.085698	37
9.802589	9.888030	9.914560	10.085440	36
9.802743	9.887926	9.914817	10.085183	35
9.802897	9.887822	9.915075	10.084925	34
9.803050	9.887718	9.915332	10.084668	33
9.803204	9.887614	9.915590	10.084410	32
9.803357	9.887510	9.915847	10.084153	31
9.803510	9.887406	9.916104	10.083895	30
9.803664	9.887302	9.916361	10.083638	29
9.803817	9.887198	9.916619	10.083381	28
9.803970	9.887093	9.916876	10.083123	27
9.804123	9.886989	9.917134	10.082866	26
9.804276	9.886884	9.917391	10.082609	25
9.804428	9.886780	9.917648	10.082352	24
9.804581	9.886675	9.917905	10.082094	23
9.804734	9.886571	9.918162	10.081837	22
9.804886	9.886466	9.918420	10.081580	21
9.805038	9.886361	9.918677	10.081323	20
9.805191	9.886257	9.918934	10.081066	19
9.805343	9.886152	9.919191	10.080809	18
9.805495	9.886047	9.919448	10.080552	17
9.805647	9.885942	9.919705	10.080295	16
9.805799	9.885837	9.919961	10.080038	15
9.805951	9.885732	9.920219	10.079781	14
9.806103	9.885627	9.920476	10.079524	13
9.806254	9.885521	9.920733	10.079267	12
9.806406	9.885416	9.920990	10.079010	11
9.806557	9.885311	9.921247	10.078753	10
9.806709	9.885205	9.921503	10.078496	9
9.806860	9.885100	9.921760	10.078240	8
9.807011	9.884994	9.922017	10.077983	7
9.807162	9.884889	9.922274	10.077726	6
9.807314	9.884783	9.922530	10.077469	5
9.807464	9.884677	9.922787	10.077213	4
9.807615	9.884572	9.923044	10.076956	3
9.807766	9.884466	9.923300	10.076699	2
9.807917	9.884360	9.923557	10.076443	1
9.808067	9.884254	9.923813	10.076186	0
Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 50.

Canon Triangulorum Logarithmicus.

Degree 40.					Degree 41.				
M	Sine	*Co-fine.*	Tangent	*Co-tang.*	Sine	*Co-fine*	Tangent	*Co-tang.*	
0	9.808067	9.884254	9.923813	10.076186	9.816943	9.877780	9.939163	10.060837	60
1	9.808218	9.884148	9.924070	10.075930	9.817088	9.877670	9.939418	10.060582	59
2	9.808368	9.884042	9.924327	10.075673	9.817233	9.877560	9.939673	10.060327	58
3	9.808519	9.883936	9.924583	10.075417	9.817378	9.877450	9.939928	10.060072	57
4	9.808669	9.883829	9.924839	10.075160	9.817523	9.877340	9.940183	10.059816	56
5	9.808819	9.883723	9.925096	10.074904	9.817668	9.877230	9.940438	10.059562	55
6	9.808969	9.883617	9.925352	10.074647	9.817813	9.877120	9.940693	10.059307	54
7	9.809119	9.883510	9.925609	10.074391	9.817958	9.877009	9.940948	10.059052	53
8	9.809269	9.883404	9.925865	10.074135	9.818103	9.876899	9.941203	10.058797	52
9	9.809419	9.883297	9.926121	10.073878	9.818247	9.876789	9.941458	10.058542	51
10	9.809569	9.883191	9.926378	10.073622	9.818392	9.876678	9.941713	10.058287	50
11	9.809718	9.883084	9.926634	10.073366	9.818536	9.876568	9.941968	10.058032	49
12	9.809868	9.882977	9.926890	10.073110	9.818681	9.876457	9.942223	10.057777	48
13	9.810017	9.882871	9.927147	10.072853	9.818825	9.876347	9.942478	10.057522	47
14	9.810166	9.882764	9.927403	10.072597	9.818969	9.876236	9.942733	10.057267	46
15	9.810316	9.882657	9.927659	10.072341	9.819113	9.876125	9.942988	10.057012	45
16	9.810465	9.882550	9.927915	10.072085	9.819257	9.876014	9.943243	10.056757	44
17	9.810614	9.882443	9.928171	10.071829	9.819401	9.875904	9.943498	10.056502	43
18	9.810763	9.882336	9.928427	10.071573	9.819545	9.875793	9.943752	10.056248	42
19	9.810912	9.882228	9.928683	10.071317	9.819689	9.875682	9.944007	10.055993	41
20	9.810061	9.882121	9.928940	10.071060	9.819832	9.875571	9.944262	10.055738	40
21	9.811210	9.882014	9.929196	10.070804	9.819976	9.875459	9.944517	10.055483	39
22	9.811358	9.881907	9.929452	10.070540	9.820119	9.875348	9.944771	10.055229	38
23	9.811506	9.881799	9.929708	10.070292	9.820263	9.875237	9.945026	10.054974	37
24	9.811655	9.881692	9.929964	10.070036	9.820406	9.875125	9.945281	10.054719	36
25	9.811804	9.881584	9.930219	10.069781	9.820549	9.875014	9.945535	10.054464	35
26	9.811952	9.881477	9.930475	10.069525	9.820693	9.874903	9.945790	10.054210	34
27	9.812100	9.881369	9.930731	10.069269	9.820836	9.874791	9.946045	10.053955	33
28	9.812248	9.881261	9.930987	10.069013	9.820979	9.874679	9.946299	10.053701	32
29	9.812396	9.881153	9.931243	10.068757	9.821122	9.874568	9.946554	10.053446	31
30	9.812544	9.881045	9.931499	10.068501	9.821264	9.874456	9.946808	10.053192	30
31	9.812692	9.880937	9.931755	10.068245	9.821407	9.874344	9.947063	10.052937	29
32	9.812840	9.880829	9.932010	10.067989	9.821550	9.874232	9.947317	10.052682	28
33	9.812988	9.880721	9.932266	10.067734	9.821692	9.874120	9.947572	10.052428	27
34	9.813135	9.880613	9.932521	10.067478	9.821835	9.874008	9.947826	10.052173	26
35	9.813283	9.880505	9.932778	10.067222	9.821977	9.873896	9.948081	10.051919	25
36	9.813430	9.880397	9.933033	10.066967	9.822120	9.873784	9.948335	10.051664	24
37	9.813578	9.880289	9.933289	10.066711	9.822262	9.873672	9.948590	10.051410	23
38	9.813725	9.880180	9.933545	10.066455	9.822404	9.873560	9.948844	10.051156	22
39	9.813872	9.880072	9.933800	10.066200	9.822546	9.873447	9.949099	10.050901	21
40	9.814019	9.879963	9.934056	10.065944	9.822688	9.873335	9.949353	10.050647	20
41	9.814166	9.879855	9.934311	10.065688	9.822830	9.873223	9.949607	10.050393	19
42	9.814313	9.879746	9.934561	10.065433	9.822972	9.873110	9.949861	10.050138	18
43	9.814460	9.879637	9.934822	10.065177	9.823114	9.872998	9.950116	10.049884	17
44	9.814607	9.879529	9.935078	10.064922	9.823255	9.872885	9.950370	10.049630	16
45	9.814753	9.879420	9.935333	10.064666	9.823397	9.872772	9.950625	10.049375	15
46	9.814900	9.879311	9.935589	10.064411	9.823538	9.872659	9.950879	10.049121	14
47	9.815046	9.879202	9.935844	10.064156	9.823680	9.872546	9.951133	10.048867	13
48	9.815193	9.879093	9.936100	10.063900	9.823821	9.872434	9.951388	10.048612	12
49	9.815339	9.878984	9.936355	10.063645	9.823962	9.872321	9.951642	10.048358	11
50	9.815485	9.878875	9.936610	10.063389	9.824104	9.872208	9.951896	10.048104	10
51	9.815631	9.878766	9.936866	10.063134	9.824245	9.872094	9.952150	10.047850	9
52	9.815777	9.878656	9.937121	10.062879	9.824386	9.871981	9.952404	10.047575	8
53	9.815923	9.878547	9.937376	10.062623	9.824527	9.871868	9.952659	10.047341	7
54	9.816069	9.878438	9.937632	10.062368	9.824667	9.871755	9.952913	10.047087	6
55	9.816215	9.878328	9.937887	10.062113	9.824808	9.871641	9.953167	10.046833	5
56	9.816361	9.878219	9.938142	10.061858	9.824949	9.871528	9.953421	10.046579	4
57	9.816506	9.878109	9.938397	10.061602	9.825090	9.871414	9.953675	10.046325	3
58	9.816652	9.877999	9.938653	10.061347	9.825230	9.871301	9.953929	10.046071	2
59	9.816797	9.877890	9.938908	10.061092	9.825370	9.871187	9.954183	10.045817	1
60	9.816943	9.877780	9.939163	10.060837	9.825511	9.871073	9.954437	10.045562	0
	Co-fine	Sine	*Co-tang.*	Tangent	*Co-fine*	Sine	*Co-tang*	Tangent	M
	Degree 49.				Degree 48.				

Canon Triangulorum Logarithmicus.

Degree 42.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.825511	9.871073	9.954437	10.045562
1	9.825651	9.870960	9.954691	10.045308
2	9.825791	9.870846	9.954945	10.045054
3	9.825931	9.870732	9.955199	10.044800
4	9.826071	9.870618	9.955453	10.044546
5	9.826211	9.870504	9.955707	10.044292
6	9.826351	9.870390	9.955961	10.044038
7	9.826491	9.870275	9.956215	10.043784
8	9.826631	9.870161	9.956469	10.043531
9	9.826770	9.870047	9.956723	10.043276
10	9.826910	9.869933	9.956977	10.043023
11	9.827049	9.869818	9.957231	10.042769
12	9.827189	9.869704	9.957485	10.042515
13	9.827328	9.869589	9.957739	10.042261
14	9.827467	9.869474	9.957993	10.042007
15	9.827606	9.869360	9.958146	10.041753
16	9.827745	9.869245	9.958500	10.041500
17	9.827884	9.869130	9.958754	10.041246
18	9.828023	9.869015	9.959008	10.040992
19	9.828162	9.868900	9.959262	10.040738
20	9.828301	9.868785	9.959515	10.040485
21	9.828439	9.868670	9.959969	10.040231
22	9.828578	9.868555	9.960023	10.039977
23	9.828716	9.868439	9.960277	10.039723
24	9.828855	9.868324	9.960530	10.039469
25	9.828993	9.868209	9.960784	10.039216
26	9.829131	9.868093	9.961038	10.038962
27	9.829269	9.867978	9.961291	10.038608
28	9.829407	9.867862	9.961545	10.038451
29	9.829545	9.867747	9.961799	10.038201
30	9.829683	9.867631	9.962052	10.037947
31	9.829821	9.867515	9.962306	10.037694
32	9.829959	9.867399	9.962560	10.037440
33	9.830096	9.867283	9.962813	10.037187
34	9.830234	9.867167	9.963067	10.036933
35	9.830372	9.867051	9.963320	10.036680
36	9.830509	9.866935	9.963574	10.036426
37	9.830646	9.866819	9.963827	10.036173
38	9.830784	9.866703	9.964081	10.035919
39	9.830921	9.866586	9.964335	10.035665
40	9.831058	9.866470	9.964588	10.035412
41	9.831195	9.866353	9.964842	10.035158
42	9.831332	9.866237	9.965095	10.034905
43	9.831469	9.866120	9.965348	10.034652
44	9.831606	9.866004	9.965602	10.034398
45	9.831742	9.865887	9.965855	10.034144
46	9.831879	9.865770	9.966109	10.033891
47	9.832015	9.865653	9.966362	10.033638
48	9.832152	9.865536	9.966616	10.033384
49	9.832288	9.865419	9.966869	10.033131
50	9.832425	9.865302	9.967122	10.032878
51	9.832561	9.865185	9.967376	10.032624
52	9.832697	9.865068	9.967629	10.032371
53	9.832833	9.864950	9.967883	10.032117
54	9.832969	9.864833	9.968136	10.031864
55	9.833105	9.864716	9.968389	10.031611
56	9.833241	9.864598	9.968643	10.031357
57	9.833376	9.864480	9.968896	10.031104
58	9.833512	9.864363	9.969149	10.030851
59	9.833648	9.864245	9.969403	10.030597
60	9.833782	9.864127	9.969656	10.030344

Co fine	Sine	*Co-tang.*	Tangent

Degree 47.

Degree 43.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.833783	9.864127	9.969656	10.030344	60
9.833919	9.864010	9.969909	10.030091	59
9.834054	9.863892	9.970162	10.029838	58
9.834189	9.863774	9.970416	10.029584	57
9.834324	9.863656	9.970669	10.029331	56
9.834460	9.863537	9.970922	10.029078	55
9.834595	9.863419	9.971175	10.028827	54
9.834730	9.863301	9.971428	10.028571	53
9.834865	9.863183	9.971682	10.028318	52
9.834999	9.863064	9.971935	10.028065	51
9.835134	9.862946	9.972188	10.027812	50
9.835269	9.862827	9.972441	10.027559	49
9.835503	9.862709	9.972694	10.027306	48
9.835538	9.862590	9.972948	10.027052	47
9.835672	9.862471	9.973201	10.026799	46
9.835806	9.862353	9.973454	10.026546	45
9.835941	9.862234	9.973707	10.026293	44
9.836075	9.862115	9.973960	10.026040	43
9.836209	9.861996	9.974213	10.025787	42
9.836343	9.861877	9.974466	10.025533	41
9.836477	9.861757	9.974719	10.025280	40
9.836611	9.861638	9.974973	10.025027	39
9.836745	9.861519	9.975229	10.024774	38
9.836878	9.861399	9.975479	10.024521	37
9.837012	9.861280	9.975732	10.024268	36
9.837146	9.861161	9.975985	10.024015	35
9.837279	9.861041	9.976238	10.023762	34
9.837412	9.860921	9.976491	10.023509	33
9.837546	9.860802	9.976744	10.023256	32
9.837679	9.860682	9.976997	10.023003	31
9.837812	9.860562	9.977250	10.022750	30
9.837945	9.860442	9.977503	10.022497	29
9.838078	9.860322	9.977756	10.022244	28
9.838211	9.860201	9.978009	10.021991	27
9.838344	9.860082	9.978262	10.021738	26
9.838477	9.859961	9.978515	10.021485	25
9.838609	9.859842	9.978768	10.021232	24
9.838741	9.859721	9.979021	10.020979	23
9.838875	9.859601	9.979274	10.020726	22
9.839007	9.859480	9.979527	10.020473	21
9.839140	9.859360	9.979780	10.020220	20
9.839272	9.859239	9.980033	10.019967	19
9.839404	9.859118	9.980285	10.019714	18
9.839536	9.858998	9.980538	10.019461	17
9.839668	9.858877	9.980791	10.019209	16
9.839800	9.858756	9.981044	10.018956	15
9.839932	9.858634	9.981297	10.018703	14
9.840064	9.858514	9.981550	10.018450	13
9.840196	9.858398	9.981803	10.018197	12
9.840428	9.858272	9.982056	10.017944	11
9.840459	9.858150	9.982309	10.017691	10
9.840591	9.858029	9.982562	10.017438	9
9.840722	9.857908	9.982814	10.017185	8
9.840854	9.857786	9.983067	10.016933	7
9.840985	9.857665	9.983320	10.016680	6
9.841116	9.857543	9.983573	10.016427	5
9.841247	9.857421	9.983826	10.016174	4
9.841378	9.857300	9.984079	10.015921	3
9.841509	9.857178	9.984331	10.015668	2
9.841640	9.857056	9.984584	10.015416	1
9.841771	9.856934	9.984837	10.015163	0

Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 46

Canon Triangulorum Logarithmicus.

Degree 44.

M	Sine	*Co-fine*	Tangent	*Co-tang.*	
0	9.841771	9.856934	9.984837	10.015162	60
1	9.841902	9.856812	9.985090	10.014910	59
2	9.842033	9.856690	9.985343	10.014657	58
3	9.842163	9.856568	9.985596	10.014404	57
4	9.842294	9.856445	9.985848	10.014151	56
5	9.842424	9.856323	9.986101	10.013899	55
6	9.842555	9.856201	9.986354	10.013646	54
7	9.842685	9.856078	9.986607	10.013393	53
8	9.842815	9.855956	9.986859	10.013140	52
9	9.842945	9.855833	9.987112	10.012888	51
10	9.843076	9.855710	9.987365	10.012635	50
11	9.843206	9.855588	9.987618	10.012382	49
12	9.843336	9.855465	9.987871	10.012129	48
13	9.843465	9.855342	9.988123	10.011877	47
14	9.843595	9.855219	9.988376	10.011614	46
15	9.843725	9.855096	9.988629	10.011371	45
16	9.843855	9.854973	9.988882	10.011118	44
17	9.843984	9.854850	9.989134	10.010866	43
18	9.844114	9.854727	9.989387	10.010613	42
19	9.844243	9.854603	9.989640	10.010360	41
20	9.844372	9.854480	9.989893	10.010107	40
21	9.844502	9.854356	9.990145	10.009855	39
22	9.844631	9.854233	9.990398	10.009602	38
23	9.844760	9.854109	9.990651	10.009349	37
24	9.844889	9.853986	9.990903	10.009096	36
25	9.845018	9.853862	9.991156	10.008844	35
26	9.845147	9.853738	9.991409	10.008591	34
27	9.845276	9.853614	9.991662	10.008338	33
28	9.845404	9.853490	9.991914	10.008086	32
29	9.845533	9.853366	9.992167	10.007833	31
30	9.845662	9.853242	9.992420	10.007580	30
31	9.845790	9.853118	9.992672	10.007328	29
32	9.845919	9.852994	9.992925	10.007075	28
33	9.846047	9.852869	9.993178	10.006822	27
34	9.846175	9.852745	9.993430	10.006569	26
35	9.846304	9.852620	9.993683	10.006317	25
36	9.846432	9.852496	9.993936	10.006064	24
37	9.846560	9.852371	9.994189	10.005811	23
38	9.846688	9.852246	9.994441	10.005559	22
39	9.846816	9.852121	9.994694	10.005306	21
40	9.846944	9.851997	9.994947	10.005053	20
41	9.847071	9.851872	9.995199	10.004801	19
42	9.847199	9.851747	9.995452	10.004548	18
43	9.847327	9.851622	9.995701	10.004295	17
44	9.847454	9.851497	9.995957	10.004043	16
45	9.847582	9.851372	9.996210	10.003790	15
46	9.847709	9.851246	9.996463	10.003537	14
47	9.847836	9.851121	9.996715	10.003285	13
48	9.847964	9.850996	9.996968	10.003032	12
49	9.848091	9.850870	9.997220	10.002779	11
50	9.848218	9.850745	9.997473	10.002527	10
51	9.848345	9.850619	9.997726	10.002274	9
52	9.848472	9.850493	9.997979	10.002021	8
53	9.848599	9.850367	9.998231	10.001769	7
54	9.848726	9.850242	9.998484	10.001516	6
55	9.848852	9.850116	9.998737	10.001263	5
56	9.848979	9.849990	9.998989	10.001011	4
57	9.849106	9.849864	9.999242	10.000758	3
58	9.849232	9.849737	9.999495	10.000505	2
59	9.849359	9.849611	9.999747	10.000253	1
60	9.849485	9.849485	10.000000	10.000000	0
	Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 45.

CHILIADES
DECEM
LOGARITHMORUM,
SHEWING
The LOGARITHMES of all NUMBERS
Increasing by Natural Succession from an Unite to 10000:
Whereby the *Logarithmes* of all *Numbers* under 1000000 may be speedily deduced.

First Calculated by that Excellent Mathematician

Mr. *HENRY BRIGGS*,

Professor of *Geometry* in the University of *Oxford*.

And their Use now Amplified,

By Capt. SAMUEL STURMY.

N	*Log.*	N	*Log.*	N	*Log.*	N	*Log.*	N	*Log.*
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342422	42	1.623249	62	1.792391	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799340	83	1.919078
4	0.602060	24	1.380211	44	1.643452	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653212	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431364	47	1.672098	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944482
9	0.954242	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954242
11	1.041393	31	1.491361	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.531479	54	1.732394	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740362	75	1.875061	95	1.977723
16	1.204120	36	1.556303	56	1.748188	76	1.880813	96	1.982271
17	1.230449	37	1.568202	57	1.755875	77	1.886491	97	1.986772
18	1.255272	38	1.579783	58	1.763428	78	1.892094	98	1.991226
19	1.278753	39	1.591064	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	2.000000

LONDON,
Printed by *E. Cotes*, *Anno Domini* 1669.

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The Table of Logarithmes.

N	0	1	2	3	4	5	6	7	8	9	D
100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
101	004321	004751	005181	005609	006038	006466	006894	007321	007748	008174	428
102	008600	009026	009451	009876	010299	010724	011147	011570	011993	012415	424
103	012837	013259	013679	014100	014521	014940	015359	015779	016197	016616	419
104	017033	017451	017868	018284	018700	019116	019532	019947	020361	020775	416
105	021189	021603	022016	022428	022841	023252	023664	024075	024486	024896	412
106	025306	025715	026125	026533	026942	027349	027757	028164	028571	028978	408
107	029384	029789	030195	030599	031004	031408	031812	032216	032619	033021	404
108	033424	033826	034227	034628	035029	035429	035829	036229	036629	037028	400
109	037426	037825	038223	038620	039017	039414	039811	040207	040602	040998	396
110	041393	041787	042182	042576	042969	043362	043755	044148	044539	044932	393
111	045323	045714	046105	046495	046885	047275	047664	048053	048442	048830	389
112	049218	049603	049993	050379	050766	051153	051538	051924	052309	052694	386
113	053078	053466	053846	054229	054613	054996	055378	055760	056142	056524	382
114	056905	057283	057666	058046	058426	058805	059185	059563	059942	060320	379
115	060698	061075	061452	061829	062206	062581	062958	063333	063709	064033	376
116	064458	064832	065206	065579	065953	066326	066699	067071	067443	067815	372
117	068186	068557	068928	069298	069668	070038	070407	070776	071145	071514	369
118	071882	072249	072617	072985	073352	073718	074085	074451	074816	075182	366
119	075547	075912	076276	076640	077004	077368	077731	078094	078457	078819	363
120	079181	079543	079904	080266	080626	080987	081347	081707	082067	082426	360
121	082785	083144	083503	083861	084219	084576	084934	085291	085647	086004	357
122	086359	086716	087071	087426	087781	088136	088490	088845	089198	089552	355
123	089905	090258	090610	090963	091315	091667	092018	092369	092721	093071	351
124	093422	093772	094122	094471	094820	095169	095518	095866	096215	096562	349
125	096910	097257	097604	097951	098298	098644	098989	099335	099681	100026	346
126	100371	100715	101059	101403	101747	102091	102434	102777	103119	103462	343
127	103804	104146	104487	104828	105169	105510	105851	106191	106531	106871	340
128	107209	107549	107888	108227	108565	108903	109241	109579	109916	110253	338
129	110589	110926	111263	111599	111934	112269	112605	112939	113275	113609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116939	333
131	117271	117603	117934	118265	118595	118926	119256	119586	119915	120245	330
132	120574	120903	121231	121559	121888	122216	122544	122871	123198	123525	328
133	123852	124178	124504	124830	125156	125481	125806	126131	126456	126781	325
134	127105	127429	127753	128076	128399	128722	129045	129368	129689	130012	323
135	130334	130655	130977	131298	131619	131939	132259	132579	132899	133219	321
136	133539	133858	134177	134496	134814	135133	135451	135769	136086	136403	318
137	136721	137037	137354	137671	137987	138303	138618	138934	139249	139564	315
138	139879	140194	140508	140822	141136	141449	141763	142076	142389	142702	314
139	143015	143327	143639	143951	144263	144574	144885	145196	145507	145818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
141	149219	149527	149835	150142	150449	150756	151063	151369	151676	151982	307
142	152288	152594	152899	153205	153509	153815	154119	154423	154728	155032	305
143	155336	155639	155943	156246	156549	156852	157154	157457	157759	158061	303
144	158362	158664	158965	159266	159567	159868	160168	160469	160769	161068	301
145	161368	161667	161967	162266	162564	162863	163161	163459	163758	164055	299
146	164353	164650	164947	165244	165541	165838	166134	166430	166726	167022	297
147	167317	167613	167908	168203	168497	168792	169086	169380	169674	169968	295
148	170261	170555	170848	171141	171434	171726	172019	172311	172603	172895	293
149	173186	173478	173769	174059	174351	174641	174932	175222	175512	175802	291

The Table of Logarithmes.

N	0	1	2	3	4	5	6	7	8	9	D
150	176091	176381	176669	176959	177248	177536	177825	178113	178401	178689	289
151	178977	179264	179552	179839	180126	180413	180699	180986	181272	181558	287
152	181844	182129	182415	182699	182985	183269	183555	183839	184123	184407	285
153	184691	184975	185259	185542	185825	186108	186391	186674	186956	187239	283
54	187521	187803	188084	188366	188647	188928	189209	189490	189771	190051	281
155	190332	190612	190892	191171	191451	191730	192009	192289	192567	192846	279
156	193125	193403	193681	193959	194237	194514	194792	195069	195346	195623	278
157	195899	196176	196453	196729	197005	197281	197556	197832	198107	198382	276
158	198657	198932	199206	199481	99755	200029	200303	200577	200850	201124	274
159	201397	201670	201943	202216	202488	202761	203033	203303	203577	203848	272
160	204119	204391	204663	204934	205204	205475	205746	206016	206286	206556	271
161	206826	207096	207365	207364	207904	208173	208441	208710	208978	209247	269
162	209515	209783	210051	210319	210586	210853	211121	211388	211654	211921	267
163	212187	212454	212720	212986	213252	213518	213783	214049	214314	214579	266
164	214844	215109	215373	215638	215902	216166	216429	216694	216957	217221	264
165	217484	217747	218010	218273	218536	218798	219060	219323	219585	219846	262
166	220108	220369	220631	220892	221153	221414	221675	221936	222196	222456	161
167	222716	222976	223236	223496	223755	224015	224274	224533	224791	225051	259
168	225309	225568	225826	226084	226341	226599	226858	227115	227372	227629	258
169	227887	228142	228400	228657	228913	229169	229426	229682	229938	230193	256
170	230449	230704	230959	231215	231469	231724	231979	232234	232488	232742	254
171	232996	233250	233504	233757	234011	234264	234517	234770	235023	235276	253
172	235528	235781	236033	236285	236537	236789	237041	237292	237544	237795	252
173	238046	238297	238548	238799	239049	239299	239549	239799	240049	240299	250
174	240549	240799	241048	241297	241546	241795	242044	242293	242541	242789	249
175	243038	243286	243534	243782	244029	244277	244525	244772	245019	245266	248
176	245513	245759	246006	246252	246499	246745	246991	247237	247482	247728	246
177	247973	248219	248464	248709	248954	249198	249443	249687	249932	250176	245
178	250420	250664	250908	251151	251395	251638	251881	252125	252368	252610	243
179	252853	253096	253334	253580	253822	254064	254306	254548	254789	255031	242
180	255273	255514	255755	255996	256237	256477	256718	256958	257198	257438	241
181	257679	257918	258158	258398	258637	258877	259116	259355	259594	259833	239
182	260071	260309	260548	260787	261025	261263	261501	261739	261976	262214	238
183	262451	262688	262925	263162	263399	263636	263873	264109	264346	264582	237
184	264818	265054	265289	265525	265761	265996	266232	266467	266702	266937	235
185	267172	267406	267641	267875	268109	268344	268578	268812	269046	269279	234
186	269513	269746	269979	270213	270446	270679	270912	271144	271377	271609	233
187	271842	272074	272306	272538	272769	273001	273233	273464	273696	273927	232
188	274158	274389	274619	274850	275081	275311	275542	275772	276002	276232	230
189	276462	276692	276921	277151	277379	277609	277838	278067	278296	278525	229
190	278754	278982	279211	279439	279667	279895	280123	280351	280578	280806	228
191	281033	281261	281488	281714	281942	282169	282396	282622	282849	283075	227
192	283301	283527	283753	283979	284205	284431	284656	284882	285107	285332	226
193	285557	285782	286007	286232	286456	286681	286905	287129	287354	287578	225
194	287801	288026	288249	288473	288696	288919	289143	289366	289589	289812	223
195	290035	290257	290479	290702	290925	291147	291369	291591	291813	292034	222
196	292256	292478	292699	292920	293141	293362	293584	293804	294025	294246	221
197	294466	294687	294907	295127	295347	295567	295787	296007	296226	296446	220
198	296665	296884	297104	297323	297542	297761	297979	298198	298416	298635	219
199	298853	299071	299289	299507	299725	299943	300161	300378	300595	300813	218

The Table of Logarithmes.

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201	303196	303412	303628	303844	304059	304275	304491	304706	304921	305136	216
202	305351	305566	305781	305996	306211	306425	306639	306854	307068	307282	215
203	307496	307709	307924	308137	308351	308564	308778	308991	309204	309417	213
204	309630	309843	310056	310268	310481	310693	310906	311118	311329	311542	212
205	311754	311966	312177	312389	312600	312812	313023	313234	313445	313656	211
206	313867	314078	314289	314499	314709	314920	315130	315340	315551	315760	210
207	315970	316180	316389	316599	316809	317018	317227	317436	317646	317854	209
208	318063	318272	318481	318689	318898	319106	319314	319522	319730	319938	208
209	320146	320354	320562	320769	320977	321184	321391	321598	321805	322012	207
210	322219	322426	322633	322839	323046	323252	323458	323665	323871	324077	206
211	324282	324488	324694	324899	325105	325310	325516	325721	325926	326131	205
212	326336	326541	326745	326949	327155	327359	327563	327767	327972	328176	204
213	328379	328583	328787	328991	329194	329398	329601	329805	330008	330211	203
214	330414	330617	330819	331022	331225	331427	331629	331832	332034	332236	202
215	332438	332640	332842	333044	333246	333447	333649	333859	334051	334253	202
216	334454	334655	334856	335057	335257	335458	335658	335859	336059	336259	201
217	336459	336659	336859	337059	337259	337459	337659	337859	338058	338257	200
218	338456	338556	338856	339054	339253	339453	339650	339849	340047	340246	199
219	340444	340642	340841	341039	341237	341435	341632	341830	342028	342225	198
220	342227	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
221	344392	344589	344785	344981	345178	345737	345569	345766	345962	346157	196
222	346353	346549	346744	346939	347135	347330	347525	347720	347915	348110	195
223	348305	348499	348694	348889	349083	349278	349472	349659	349860	350054	194
224	350248	350442	350636	350829	351023	351216	351409	351603	351796	351989	193
225	352183	352375	352568	352761	352954	353147	353339	353532	353724	353916	193
226	354108	354301	354493	354685	354876	355068	355259	355452	355643	355834	192
227	356026	356217	356408	356599	356792	356981	357172	357363	357554	357744	191
228	357935	358125	358316	358506	358696	358886	359076	359266	359456	359646	190
229	359835	360025	360215	360404	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
231	363612	363799	363988	364176	364363	364551	364739	364926	365113	365301	188
232	365488	365675	365862	366049	366236	366423	366609	366796	366983	367169	187
233	367356	367542	367729	367915	368101	368287	368473	368659	368845	369030	186
234	369216	369401	369587	369772	369958	370143	370328	370513	370698	370882	185
235	371068	371253	371437	371621	371806	371991	372175	372359	372544	372728	184
236	372912	373096	373279	373464	373647	373831	374015	374198	374382	374565	184
237	374748	374931	375115	375298	375481	375664	375846	376029	376212	376394	183
238	376577	376759	376942	377124	377306	377488	377670	377852	378034	378216	182
239	378398	378579	378761	378943	379124	379306	379487	379668	379849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
241	382017	382197	382377	382557	382737	382917	383097	383277	383456	383636	180
242	383815	383995	384174	384353	384533	384712	384891	385069	385249	385428	179
243	385606	385785	385964	386142	386321	386499	386677	386856	387034	387212	178
244	387389	387568	387746	387923	388101	388279	388456	388634	388811	388989	178
245	389166	389343	389520	389698	389875	390051	390228	390405	390582	390759	177
246	390935	391112	391288	391464	391641	391817	391993	392169	392345	392521	176
247	392697	392873	393048	393224	393399	393575	393751	393926	394101	394277	176
248	394452	394627	394802	394977	395152	395326	395501	395676	395850	396025	175
249	396199	396374	396548	396722	396896	397071	397245	397419	397592	397766	174

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251	399674	399847	400019	400192	400365	400538	400711	400883	401056	401228	173
252	401401	401573	401745	401917	402089	402261	402433	402605	402777	402949	172
253	403121	403292	403464	403635	403807	403978	404149	404320	404492	404663	171
254	404834	405005	405176	405346	405517	405688	405858	406029	406199	406369	171
255	406540	406710	406881	407051	407221	407391	407561	407731	407901	408070	170
256	408239	408409	408579	408749	408918	409087	409257	409426	409595	409764	169
257	409933	410102	410271	410439	410609	410777	410946	411114	411283	411451	169
258	411619	411788	411956	412124	412293	412461	412629	412796	412964	413132	168
259	413299	413467	413635	413803	413969	414137	414305	414472	414639	414806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
261	416641	416807	416973	417139	417306	417472	417638	417804	417969	418135	166
262	418301	418467	418633	418798	418964	419129	419295	419460	419625	419791	165
263	419956	420121	420286	420451	420616	420781	420945	421110	421275	421439	165
264	421604	421768	421933	422097	422261	422426	422589	422754	422918	423082	164
265	423246	423409	423574	423737	423901	424065	424228	424392	424555	424718	164
266	424882	425045	425208	425371	425534	425697	425860	426023	426186	426349	163
267	426511	426674	426836	426999	427161	427324	427486	427648	427811	427973	162
268	428135	428297	428459	428621	428783	428944	429106	429268	429429	429591	162
269	429752	429914	430075	430236	430398	430559	430719	430881	431042	431203	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
271	432969	433129	433289	433449	433609	433769	433929	434089	434249	434409	160
272	434569	434729	434888	435048	435207	435366	435526	435685	435844	436004	159
273	436163	436322	436481	436639	436799	436957	437116	437275	437433	437592	159
274	437751	437909	438067	438226	438384	438542	438701	438859	439017	439175	158
275	439333	439491	439648	439806	439964	440122	440279	440437	440594	440752	158
276	440909	441066	441224	441381	441538	441695	441852	442009	442166	442323	157
277	442479	442637	442793	442949	443106	443263	443419	443576	443732	443889	157
278	444045	444201	444357	444513	444669	444825	444981	445137	445293	445449	156
279	445604	445759	445915	446071	446226	446382	446537	446692	446848	447003	155
280	447158	447313	447468	447623	447778	447932	448088	448242	448397	448552	155
281	448706	448861	449015	449169	449324	449478	449633	449787	449941	450095	154
282	450249	450403	450557	450711	450865	451018	451172	451326	451479	451633	154
283	451786	451939	452093	452247	452399	452553	452706	452859	453012	453165	153
284	453318	453471	453624	453777	453929	454082	454235	454387	454539	454692	153
285	454845	454997	455149	455302	455454	455606	455758	455910	456061	456214	152
286	456366	456518	456669	456821	456973	457125	457276	457428	457579	457731	152
287	459889	458033	458184	458336	458487	458638	458789	458939	459091	459242	151
288	459392	459543	459694	459845	459995	460146	460256	460447	460597	460748	151
289	460898	461048	461198	461348	461499	461649	461799	461948	462098	462248	150
290	462398	462548	462697	462847	462997	463146	463296	463445	463594	463744	150
291	463893	464042	464191	464340	464489	464639	464787	464936	465085	465234	149
292	465383	465532	465680	465829	465977	466126	466274	466423	466571	466719	149
293	466868	467016	467164	467312	467460	467608	467756	467904	468052	468199	148
294	468347	468495	468643	468790	468798	469085	469233	469380	469527	469675	147
295	469822	469969	470116	470263	470410	470557	470704	470851	470998	471145	147
296	471292	471438	471585	471732	471878	472025	472171	472318	472464	472610	146
297	472756	472903	473049	473195	473341	473487	473633	473779	473925	474071	146
298	474216	474361	474508	474653	474799	474944	475089	475235	475381	475526	146
299	475671	475816	475962	476107	476252	476397	476542	476687	476832	476976	145

The Table of Logarithmes.

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302	480007	480151	480294	480438	480582	480725	480869	481012	481156	481299	144
303	481443	481586	481729	481872	482016	482159	482302	482445	482588	482731	143
304	482874	483016	483159	483302	483445	483587	483729	483872	484015	484157	143
305	484299	484442	484585	484727	484869	485011	485153	485295	485437	485579	142
306	485721	485863	486005	486147	486289	486430	486572	486714	486855	486997	142
307	487138	487279	487421	487563	487704	487845	487986	488127	488269	488409	141
308	488551	488692	488833	488974	489114	489255	489396	489537	489677	489818	141
309	489958	490099	490239	490379	490520	490661	490801	390941	491081	491222	140
310	491362	491502	491642	491782	491922	492062	492201	492341	492481	492621	140
311	492760	492900	493039	493179	493319	493458	493597	493737	493876	494015	139
312	494155	494294	494433	494572	494711	494850	494989	495128	495267	495406	139
313	495544	495683	495822	495960	496099	496238	496376	496515	496653	496791	139
314	496929	497068	497206	497344	497483	497621	497759	497897	498035	498173	138
315	498311	498448	498586	498724	498862	498999	499137	499275	499412	499549	138
316	499687	499824	499962	500099	500236	500374	500510	500648	500785	500922	137
317	501059	501196	501333	501470	501607	501744	501880	502017	502154	502291	137
318	502417	502564	502700	502837	502973	503109	503246	503382	503518	503655	136
319	503791	503927	504063	504199	504335	504471	504607	504743	504878	505014	136
320	505149	505286	505421	505557	505693	505828	505964	506099	506234	506369	136
321	506505	506640	506776	506911	507046	507181	507316	507451	507586	507721	135
322	507856	507991	508126	508260	508395	508529	508664	50879,	508934	509068	135
323	509203	509337	509471	509606	509740	509874	510009	510143	510177	510411	134
324	510545	510679	510813	510947	511081	511215	511349	511482	511616	511749	134
325	511883	512017	512151	512284	512418	512551	512684	512818	512951	513084	133
326	513218	513351	513484	513617	513750	513883	514016	514149	514282	514415	133
327	514548	514681	514813	514946	515079	515211	515344	515476	515609	515741	133
328	515874	516006	516139	516271	516403	516535	516668	516799	516932	517064	132
329	517196	517328	517455	517592	517724	517855	517987	518119	518251	518382	132
330	518514	518646	518777	518909	519040	519171	519303	519434	519566	519697	131
331	519828	519959	520090	520221	520353	520484	520615	520745	520876	521007	131
332	521138	521269	521399	521530	521661	521792	521922	522053	522183	522314	131
333	522444	522575	522705	522835	522966	523096	523226	523356	523486	523616	130
334	523746	523876	524006	524136	524266	524396	524526	524656	524785	524915	130
335	525045	525174	525304	525434	525563	525693	525822	525951	526081	526210	129
336	526339	526469	526598	526727	526856	526985	527114	527243	527372	527501	129
337	527629	527759	527888	528016	528145	528274	528402	528531	528659	528788	129
338	528916	529045	529174	529302	529430	529559	529687	529815	529943	530072	128
339	530199	530328	530456	530584	530712	530839	530968	531096	531223	531351	128
340	531479	531607	531734	531862	531989	532117	532245	532372	532499	532627	128
341	532754	532882	533009	533136	533264	533391	533518	533645	533772	533899	127
342	534026	534153	534280	534407	534534	534661	534787	534914	535041	535167	127
343	535294	535421	535547	535674	535800	535927	536053	536179	536304	536432	126
344	536558	536685	536811	536937	537063	537189	537315	537441	537567	537693	126
345	537819	537945	538071	538197	538322	538448	538574	538699	538825	538951	126
346	539076	539202	539327	539452	539578	539703	539829	539954	540079	540204	125
347	540329	540455	540579	540705	540829	540955	541079	541205	541329	541454	125
348	541579	541704	541829	541953	542078	542203	542327	542452	542576	542701	125
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351	545307	545421	545555	545678	545802	545925	546049	546172	546296	546419	124
352	546543	546666	546789	546913	547036	547159	547282	547405	547529	547652	123
353	547775	547898	548021	548144	548267	548389	548512	548635	548758	548881	123
354	549003	549126	549249	549371	549494	549616	549739	549861	549984	550106	123
355	550228	550351	550473	550595	550717	550839	550962	551084	551206	551328	122
356	551449	551572	551694	551816	551938	552059	552181	552303	552425	552547	122
357	552668	552789	552911	553033	553155	553276	553398	553519	553640	553762	121
358	553883	554004	554126	554247	554368	554489	554610	554731	554852	554973	121
359	555094	555215	555336	555457	555578	555699	555819	555940	556061	556182	121
360	556303	556423	556544	556664	556785	556905	557026	557146	557267	557387	120
361	557507	557627	557748	557868	557988	558108	558228	558349	558469	558589	120
362	558709	558829	558948	559068	559188	559308	559428	559548	559667	559787	120
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747	873321	873379	873437	873495	873553	873611	873669	873727	873785	873844	58
748	873902	873959	874018	874076	874134	874192	874249	874308	874366	874424	58
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755	877947	878004	878062	878119	878177	878234	878291	878349	878407	878464	57
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767	884795	884852	884909	884965	885022	885078	885135	885192	885248	885305	57
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920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
921	964259	964307	964354	964401	964448	964495	964542	964589	964637	964684	47
922	964731	964778	964825	964872	964919	964966	965013	965061	965108	965155	47
923	965202	965249	965296	965343	965389	965437	965484	965531	965578	965614	47
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926	966611	966658	966705	966752	966799	966845	966892	966939	966986	967033	47
927	967079	967127	967173	967220	967267	967314	967361	967408	967454	967501	47
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930	968483	968529	968576	968623	968669	968716	968763	968809	968856	968902	47
931	968949	968996	969043	969089	969136	969183	969229	969276	969323	969369	47
932	969416	969463	969509	969556	969602	969649	969695	969741	969789	969835	47
933	969882	969928	969975	970021	970068	970114	970161	970207	970254	970300	47
934	970347	970393	970439	970486	970533	970579	970626	970672	970719	970765	46
935	970812	970858	970904	970951	970997	971044	971090	971137	971183	971229	46
936	971276	971322	971369	971415	971461	971508	971554	971601	971647	971693	46
937	971739	971786	971832	971879	971925	971971	972018	972064	972110	972157	46
938	972203	972249	972295	972342	972388	972434	972481	972527	972573	972619	46
939	972666	972712	972758	972804	972851	972897	972943	972989	973035	973082	46
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
941	973589	973636	973682	973728	973774	973820	973866	973913	973959	974005	46
942	974050	974097	974143	974189	974235	974281	974327	974374	974419	974466	46
943	974512	974558	974604	974649	974695	974742	974788	974834	974819	974926	46
944	974972	975018	975064	975109	975156	975201	975248	975294	975339	975386	46
945	975432	975478	975524	975569	975616	975662	975707	975753	975799	975845	46
946	975891	975937	975983	976029	976075	976121	976167	976212	976258	976304	46
947	976349	976396	976442	976488	976533	976579	976625	976671	976717	976763	46
948	976808	976854	976899	976946	976992	977037	977083	977129	977175	977220	46
949	977266	977312	977358	977403	977449	977495	977541	977586	977632	977678	46

N	0	1	2	3	4	5	6	7	8	9	D
950	977724	977769	977815	977861	977906	977952	977998	978042	978089	978135	46
951	978181	978226	978272	978317	978363	978409	978454	978500	978546	978591	46
952	978637	978683	978728	978774	978819	978865	978911	978956	979002	979047	46
953	979093	979138	979184	979229	979275	979321	979366	979412	979457	979503	46
954	979548	979594	979639	979685	979730	979776	979821	979867	979912	979958	46
955	980003	980049	980094	980139	980185	980231	980276	980321	980367	980412	45
956	980458	980503	980549	980594	980639	980685	980730	980776	980821	980867	45
957	980912	980957	981003	981048	981093	981139	981184	981229	981275	981320	45
958	981366	981411	981456	981501	981547	981592	981637	981683	981728	981773	45
959	981819	981864	981909	981954	981999	982045	982090	982135	982181	982226	45
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
961	982723	982769	982814	982859	982904	982949	982994	983039	983085	983129	45
962	983175	983220	983265	983310	983356	983401	983446	983490	983536	983581	45
963	983626	983671	983716	983762	983807	983852	983897	983942	983987	984032	45
964	984077	984122	984167	984212	984257	984302	984347	984392	984437	984482	45
965	984527	984572	984617	984662	984707	984752	984797	984842	984887	984932	45
966	984977	985022	985067	985112	985157	985202	985247	985292	985337	985382	45
967	985426	985471	985516	985561	985606	985651	985696	985741	985786	985830	45
968	985875	985920	985965	986009	986055	986099	986144	986189	986234	986279	45
969	986324	986369	986413	986458	986504	986548	986593	986637	986682	986727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987129	987175	45
971	987219	987264	987309	987353	987398	987443	987488	987532	987577	987622	45
972	987666	987711	987756	987800	987845	987889	987934	987979	988024	988068	45
973	988113	988157	988202	988247	988291	988336	988381	988425	988469	988514	45
974	988559	988604	988648	988693	988737	988782	988826	988871	988916	988960	45
975	989005	989049	989094	989138	989183	989227	989272	989316	989361	989405	45
976	989449	989494	989539	989584	989628	989672	989717	989761	989806	989850	44
977	989895	989939	989983	990028	990072	990117	990161	990206	990250	990294	44
978	990339	990383	990428	990472	990516	990561	990605	990649	990694	990738	44
979	990783	990827	990871	990916	990960	991004	991049	991093	991137	991182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
981	991669	991713	991758	991802	991846	991890	991935	991979	992023	992067	44
982	992111	992156	992199	992244	992288	992333	992377	992421	992465	992509	44
983	992554	992598	992642	992686	992730	992774	992819	992863	992907	992951	44
984	992995	993039	993083	993127	993172	993216	993259	993304	993348	993392	44
985	993436	993480	993524	993568	993613	993657	993701	993745	993789	993833	44
986	993877	993921	993965	994009	994053	994097	994141	994185	994229	994273	44
987	994317	994361	994405	994449	994493	994537	994581	994625	994669	994713	44
988	994756	994801	994845	994889	994933	994977	995021	995065	995108	995152	44
989	995196	995240	995284	995328	995372	995416	995459	995504	995547	995591	44
990	995635	995679	995723	995764	995811	995854	995898	995942	995986	996029	44
991	996074	996117	996161	996205	996249	996293	996337	996380	996424	996468	44
992	996512	996555	996599	996643	996687	996731	996774	996818	996862	996906	44
993	996949	996993	997037	997080	997124	997168	997212	997255	997299	997343	44
994	997386	997430	997474	997517	997561	997605	997648	997692	997736	997779	44
995	997823	997867	997910	997954	997998	998041	998085	998129	998172	998216	44
996	998259	998303	998347	998390	998434	998477	998521	998564	998608	998652	44
997	998695	998739	998783	998826	998869	998913	998956	998999	999043	999087	44
998	999133	999174	999218	999261	999305	999348	999392	999435	999479	999522	44
999	999565	999609	999652	999696	999739	999783	999826	999869	999913	999957	43

A TABLE of PROPORTIONAL PARTS,

Whereby the Intermediate *Logarithmes* of all Numbers, and the Numbers of all *Logarithmes*, from 10000 to 100000, may more readily be found out by the foregoing Table of *Logarithmes*.

D	1	2	3	4	5	6	7	8	9
43	4	8	12	17	21	25	30	34	38
44	4	8	13	17	22	26	30	35	39
45	4	9	13	18	22	27	31	36	40
46	4	9	13	18	23	27	32	36	41
47	4	9	14	18	23	28	32	37	42
48	4	9	14	19	24	28	33	38	43
49	4	9	14	19	24	29	34	39	44
50	5	10	15	20	25	30	35	40	45
51	5	10	15	20	25	30	35	40	45
52	5	10	15	20	26	31	36	41	46
53	5	10	15	21	26	31	37	42	47
54	5	10	16	21	27	32	37	43	48
55	5	11	16	22	27	33	38	44	49
56	5	11	16	22	28	33	39	44	50
57	5	11	17	22	28	34	39	45	51
58	5	11	17	23	29	34	40	46	52
59	5	11	17	23	29	35	41	47	53
60	6	12	18	24	30	36	42	48	54
61	6	12	18	24	30	36	42	48	54
62	6	12	18	24	31	37	43	49	55
63	6	12	18	25	31	37	44	50	56
64	6	12	19	25	32	38	44	51	57
65	6	13	19	26	32	39	45	52	58
66	6	13	19	26	33	39	46	52	59
67	6	13	20	26	33	40	46	53	60
68	6	13	20	27	34	40	47	54	61
69	6	13	20	27	34	41	48	55	62
70	7	14	21	28	35	42	49	56	63
71	7	14	21	28	35	42	49	56	63
72	7	14	21	28	36	43	50	57	64
73	7	14	21	29	36	43	51	58	65
74	7	14	22	29	37	44	51	59	66
75	7	15	22	30	37	45	52	60	67
76	7	15	22	30	38	45	53	60	68
77	7	15	23	30	38	46	53	61	69
78	7	15	23	31	39	46	54	62	70
79	7	15	23	31	39	47	55	63	71
80	8	16	24	32	40	48	56	64	72
81	8	16	24	32	40	48	56	64	72
82	8	16	24	32	41	49	57	65	73
83	8	16	24	33	41	49	58	66	74
84	8	16	25	33	42	50	58	67	75
85	8	17	25	34	42	51	59	68	76
86	8	17	25	34	43	51	60	68	77
87	8	17	26	34	43	52	60	69	78
88	8	17	26	35	44	52	61	70	79
89	8	17	26	35	44	53	62	71	80
90	9	18	27	36	45	54	63	72	81
91	9	18	27	36	45	54	63	72	81
92	9	18	27	36	46	55	64	73	82
93	9	18	27	37	46	55	65	74	83
94	9	18	28	37	47	56	65	75	84
95	9	19	28	38	47	57	66	76	85
96	9	19	28	38	48	57	67	76	86
97	9	19	29	38	48	58	67	77	87
98	9	19	29	39	49	58	68	78	88
99	9	19	29	39	49	59	69	79	89
100	10	20	30	40	50	60	70	80	90
101	10	20	30	40	50	60	70	80	90
102	10	20	30	40	51	61	71	81	91

D	1	2	3	4	5	6	7	8	9
103	10	20	30	41	51	61	72	82	92
104	10	20	31	41	52	62	72	83	93
105	10	21	31	42	52	63	73	84	94
106	10	21	31	42	53	63	74	84	95
107	10	21	32	42	53	64	74	85	96
108	10	21	32	43	54	64	75	86	97
109	10	21	32	43	54	65	76	87	98
110	11	22	33	44	55	66	77	88	99
111	11	22	33	44	55	66	77	88	99
112	11	22	33	44	56	67	78	89	100
113	11	22	33	45	57	67	78	90	101
114	11	22	34	45	57	68	79	91	102
115	11	23	34	46	57	69	80	92	103
116	11	23	34	46	58	69	81	92	104
117	11	23	35	46	58	70	81	93	105
118	11	23	35	47	59	70	82	94	106
119	11	23	35	47	59	71	83	95	107
120	12	24	36	48	60	72	84	96	108
121	12	24	36	48	60	72	84	96	108
122	12	24	36	48	61	73	85	97	109
123	12	24	36	48	61	73	86	98	110
124	12	24	37	49	62	74	86	99	111
125	12	25	37	50	62	75	87	100	112
126	12	25	37	50	63	75	88	100	113
127	12	25	38	50	63	76	88	101	114
128	12	25	38	51	64	76	89	102	115
129	12	25	38	51	64	77	90	103	116
130	13	26	39	52	65	78	91	104	117
131	13	26	39	52	65	78	91	104	117
132	13	26	39	52	66	79	92	105	118
133	13	26	39	53	66	79	93	106	119
134	13	26	40	53	67	80	93	107	120
135	13	27	40	54	67	81	94	108	121
136	13	27	40	54	68	81	95	108	122
137	13	27	41	54	68	82	95	109	123
138	13	27	41	55	69	82	96	110	124
139	13	27	41	55	69	83	97	111	125
140	14	28	42	56	70	84	98	112	126
141	14	28	42	56	70	84	98	112	126
142	14	28	42	56	71	85	99	113	127
143	14	28	42	57	71	85	100	114	128
144	14	28	43	57	72	86	100	115	129
145	14	28	43	58	72	87	101	116	130
146	14	29	43	58	73	87	102	116	131
147	14	29	44	58	73	88	102	117	132
148	14	29	44	59	74	88	103	118	133
149	14	29	44	59	74	89	104	119	134
150	15	30	45	60	75	90	105	120	135
151	15	30	45	60	75	90	105	120	135
152	15	30	45	60	76	91	106	121	136
153	15	30	45	60	76	91	107	122	137
154	15	30	46	61	77	92	107	123	138
155	15	31	46	62	77	93	108	124	139
156	15	31	46	62	78	93	109	124	140
157	15	31	47	62	78	94	109	125	141
158	15	32	47	63	79	94	110	126	142
159	15	31	47	63	79	95	111	127	143
160	16	32	48	64	80	96	112	128	144
161	16	32	48	64	80	96	112	128	144
162	16	32	48	64	81	97	113	129	145

The Table of Proportional Parts.

D	1	2	3	4	5	6	7	8	9
163	16	32	48	65	82	98	114	130	146
164	16	32	49	66	82	98	114	131	147
165	16	33	49	66	82	99	115	132	148
166	16	33	49	66	83	99	116	132	149
167	16	33	50	66	83	100	116	133	150
168	16	33	50	67	84	100	117	134	151
169	16	33	50	67	84	101	118	135	152
170	17	34	51	68	85	102	119	136	153
171	17	34	51	68	85	102	119	136	153
172	17	34	51	68	86	103	120	137	154
173	17	34	51	69	86	103	121	138	155
174	17	34	52	69	87	104	121	139	156
175	17	34	52	70	87	105	122	140	157
176	17	35	52	70	88	105	123	140	158
177	17	35	53	70	88	106	123	141	159
178	17	35	53	71	89	106	124	142	160
179	17	35	53	71	89	107	125	143	161
180	18	36	54	72	90	108	126	144	162
181	18	36	54	72	90	108	126	144	162
182	18	36	54	72	91	109	127	145	163
183	18	36	54	73	91	109	128	146	164
184	18	36	55	73	92	110	128	147	165
185	18	37	55	74	92	111	129	148	166
186	18	37	55	74	93	111	130	148	167
187	18	37	56	74	93	112	130	149	168
188	18	37	56	75	94	112	131	150	169
189	18	37	56	75	94	113	132	151	170
190	19	38	57	76	95	114	133	152	171
191	19	38	57	76	95	114	133	152	171
192	19	38	57	76	96	115	134	153	172
193	19	38	57	77	96	115	135	154	173
194	19	38	58	77	97	116	135	155	174
195	19	39	58	78	97	117	136	156	175
196	19	39	59	78	98	117	136	156	176
197	19	39	59	78	98	118	137	157	177
198	19	39	59	79	99	118	138	158	178
199	19	39	59	79	99	119	139	159	179
200	20	40	60	80	100	120	140	160	180
201	20	40	60	80	100	120	140	160	180
202	20	40	60	80	101	121	141	161	181
203	20	40	60	81	101	121	142	162	182
204	20	40	61	81	102	122	142	163	183
205	20	41	61	82	102	123	143	164	184
206	20	41	61	82	103	123	144	164	185
207	20	41	62	82	103	124	144	165	186
208	20	41	62	83	104	124	145	166	187
209	20	41	62	83	104	125	146	167	188
210	21	42	63	84	105	126	147	168	189
211	21	42	63	84	105	126	147	168	189
212	21	42	63	84	106	127	148	169	190
213	21	42	63	85	106	127	149	170	191
214	21	42	64	85	107	128	149	171	192
215	21	43	64	86	107	129	150	172	193
216	21	43	64	86	108	129	151	172	194
217	21	43	65	86	108	130	151	173	195
218	21	43	65	87	109	130	152	174	196
219	21	43	65	87	109	131	153	175	197
220	22	44	66	88	110	132	154	176	198
221	22	44	66	88	110	132	154	176	198
222	22	44	66	88	111	133	155	177	199
223	22	44	66	89	111	133	156	178	200
224	22	44	67	89	112	134	156	179	201
225	22	45	67	90	112	135	157	180	202
226	22	45	67	90	113	135	158	180	203
227	22	45	68	90	113	136	158	181	204
228	22	45	68	91	114	136	159	182	205
229	22	45	68	91	114	137	160	183	206
230	23	46	69	92	115	138	161	184	207
231	23	46	69	92	115	138	161	184	207

D	1	2	3	4	5	6	7	8	9
232	23	46	69	92	116	139	162	185	208
233	23	46	69	93	116	139	163	186	209
234	23	46	70	93	117	140	163	187	210
235	23	47	70	94	117	141	164	188	211
236	23	47	70	94	118	141	165	188	212
237	23	47	71	94	118	142	165	189	213
238	23	47	71	95	119	142	166	190	214
239	23	47	71	95	119	143	167	191	215
240	24	48	72	96	120	144	168	192	216
241	24	48	72	96	120	144	168	192	216
242	24	48	72	96	121	145	169	193	217
243	24	48	72	97	121	145	170	194	218
244	24	48	73	97	122	146	170	195	219
245	24	49	73	98	122	147	171	196	220
246	24	49	73	98	123	147	172	196	221
247	24	49	74	98	123	148	172	197	222
248	24	49	74	99	124	148	173	198	223
249	24	49	74	99	124	149	174	199	224
250	25	50	75	100	125	150	175	200	225
251	25	50	75	100	125	150	175	200	225
252	25	50	75	100	126	151	176	201	226
253	25	50	75	101	126	151	177	202	227
254	25	50	76	101	127	152	177	203	228
255	25	50	76	102	127	153	178	204	229
256	25	51	76	102	128	153	179	204	230
257	25	51	77	102	128	154	179	205	231
258	25	51	77	103	129	154	180	206	232
259	25	51	77	103	129	155	181	207	233
260	26	52	78	104	130	156	182	208	234
261	26	52	78	104	130	156	182	208	234
262	26	52	78	104	131	156	183	209	235
263	26	52	78	105	131	157	184	210	236
264	26	52	79	105	132	158	184	211	237
265	26	53	79	106	132	159	185	212	238
266	26	53	79	106	133	159	186	212	239
267	26	53	80	106	133	160	186	213	240
268	26	53	80	107	134	160	187	214	241
269	26	53	80	107	134	161	188	215	242
270	27	54	81	108	135	162	189	216	243
271	27	54	81	108	135	162	189	216	243
272	27	54	81	108	136	163	190	217	244
273	27	54	81	109	136	163	191	218	245
274	27	54	82	109	137	164	191	219	246
275	27	55	82	110	137	165	192	220	247
276	27	55	82	110	138	165	193	220	248
277	27	55	83	110	138	166	193	221	249
278	27	55	83	111	139	166	194	222	250
279	27	55	83	111	139	167	195	223	251
280	28	56	84	112	140	168	196	224	252
281	28	56	84	112	140	168	196	224	252
282	28	56	84	112	141	169	197	225	253
283	28	56	84	113	141	169	198	226	254
284	28	56	85	113	142	170	198	227	255
285	28	57	85	114	142	171	199	228	256
286	28	57	85	114	143	171	200	228	257
287	28	57	86	114	143	172	200	229	258
288	28	57	86	115	144	172	201	230	259
289	28	57	86	115	144	173	202	231	260
290	29	58	87	116	145	174	203	232	261
291	29	58	87	116	145	174	203	232	261
292	29	58	87	116	146	175	204	233	262
293	29	58	87	117	146	175	205	234	263
294	29	58	88	117	147	176	205	235	264
295	29	59	88	118	147	177	206	236	265
296	29	59	88	118	148	177	207	236	266
297	29	59	88	118	148	178	207	237	267
298	29	59	89	119	149	178	208	238	268
299	29	59	89	119	149	179	209	239	269
300	30	60	90	120	150	180	210	240	270

D	1	2	3	4	5	6	7	8	9
301	30	60	90	120	150	180	210	240	270
302	30	60	90	120	151	181	211	241	271
303	30	60	90	121	151	181	212	242	272
304	30	60	91	121	152	182	212	243	273
305	30	61	91	122	152	183	213	244	274
306	30	61	91	122	153	183	214	244	275
307	30	61	92	122	153	184	214	245	276
308	30	61	92	123	154	184	215	246	277
309	30	61	92	123	154	185	216	247	278
310	31	62	93	124	155	186	217	248	279
311	31	62	93	124	155	186	217	248	279
312	31	62	93	124	156	187	218	249	280
313	31	62	93	125	156	187	219	250	281
314	31	62	94	125	157	188	219	251	282
315	31	63	94	126	157	189	220	252	283
316	31	63	94	126	158	189	221	252	284
317	31	63	95	126	158	190	221	253	285
318	31	63	95	127	159	190	222	254	286
319	31	63	95	127	159	191	223	255	287
320	32	64	96	128	160	192	224	256	288
321	32	64	96	128	160	192	224	256	288
322	32	64	96	128	161	193	225	257	289
323	32	64	96	129	161	193	226	258	290
324	32	64	97	129	162	194	226	259	291
325	32	65	97	130	162	195	227	260	292
326	32	65	97	130	163	195	228	260	293
327	32	65	98	130	163	196	228	261	294
328	32	65	98	131	163	196	229	262	295
329	32	65	98	131	164	197	230	263	296
330	33	66	99	132	165	198	231	264	297
331	33	66	99	132	165	198	231	264	297
332	33	66	99	132	166	199	232	265	298
333	33	66	99	133	166	199	233	266	299
334	33	66	100	133	167	200	233	267	300
335	33	67	100	134	167	201	234	268	301
336	33	67	100	134	168	201	235	268	302
337	33	67	101	134	168	202	235	269	303
338	33	67	101	135	169	202	236	270	304
339	33	67	101	135	169	203	237	271	305
340	34	68	102	136	170	204	238	272	306
341	34	68	102	136	170	204	238	272	306
342	34	68	102	136	171	205	239	273	307
343	34	68	102	137	171	205	240	274	308
344	34	68	103	137	172	206	240	275	309
345	34	69	103	138	172	207	241	276	310
346	34	69	103	138	173	207	242	276	311
347	34	69	104	138	173	208	242	277	312
348	34	69	104	139	174	208	243	278	313
349	34	69	104	139	174	209	244	279	314
350	34	70	105	140	175	210	245	280	315
351	35	70	105	140	175	210	245	280	315
352	35	70	105	140	176	211	246	281	316
353	35	70	105	141	176	211	247	282	317
354	35	70	106	141	177	212	247	283	318
355	35	71	106	142	177	213	248	284	319
356	35	71	106	142	178	213	249	284	320
357	35	71	107	142	178	214	249	285	321
358	35	71	107	143	179	214	250	286	322
359	35	71	107	143	179	215	251	287	323
360	36	72	108	144	180	216	252	288	324
361	36	72	108	144	180	216	252	288	324
362	36	72	108	144	181	217	253	289	325
363	36	72	108	145	181	217	254	290	326
364	36	72	109	145	182	218	254	291	327
365	36	73	109	146	182	219	255	292	328
366	36	73	109	146	182	219	256	292	329
367	36	73	110	146	183	220	256	293	330
368	36	73	110	147	184	220	257	294	331

D	1	2	3	4	5	6	7	8	9
369	36	73	110	147	184	221	258	295	332
370	37	74	111	148	185	222	259	296	333
371	37	74	111	148	185	222	259	296	333
372	37	74	111	148	186	223	260	297	334
373	37	74	111	149	186	223	261	298	335
374	37	74	112	149	187	224	261	299	336
375	37	75	112	150	187	225	262	300	337
376	37	75	113	150	188	225	263	300	338
377	37	75	113	150	188	226	263	301	339
378	37	75	113	151	189	226	264	302	340
379	37	75	113	151	189	227	265	303	341
380	38	76	114	152	190	228	266	304	342
381	38	76	114	152	190	228	266	304	342
382	38	76	114	152	191	229	267	305	343
383	38	76	114	153	191	229	268	306	344
384	38	76	115	153	192	230	268	307	345
385	38	77	115	154	192	231	269	308	346
386	38	77	115	154	193	231	270	308	347
387	38	77	116	154	193	232	270	309	348
388	38	77	116	155	194	232	271	310	349
389	38	77	116	155	194	233	272	311	350
390	39	78	117	156	195	233	273	312	351
391	39	78	117	156	195	233	273	312	351
392	39	78	117	156	196	234	274	313	352
393	39	78	117	157	196	235	275	314	353
394	39	78	118	157	197	236	275	315	354
395	39	79	118	158	197	237	276	316	355
396	39	79	118	158	198	237	277	316	356
397	39	79	119	158	198	238	277	317	357
398	39	79	119	159	199	238	278	318	358
399	39	79	119	159	199	239	279	319	359
400	40	80	120	160	200	240	280	320	360
401	40	80	120	160	200	240	280	320	360
402	40	80	120	160	201	241	281	321	361
403	40	80	120	161	201	241	282	321	362
404	40	80	121	161	202	242	282	323	363
405	40	81	121	162	202	243	283	324	364
406	40	81	121	162	203	243	284	324	365
407	40	81	122	162	203	244	284	325	366
408	40	81	122	163	204	244	285	326	367
409	40	81	122	163	204	245	286	327	368
410	41	82	123	164	205	246	287	328	369
411	41	82	123	164	205	246	287	328	369
412	41	82	123	164	206	247	288	329	370
413	41	82	123	165	206	247	289	330	371
414	41	82	124	165	207	248	289	331	372
415	41	83	124	166	207	249	290	332	373
416	41	83	124	166	208	249	291	332	374
417	41	83	125	166	208	250	291	333	375
418	41	83	125	167	209	250	292	334	376
419	41	83	125	167	209	251	293	335	377
420	42	84	126	168	210	252	294	336	378
421	42	84	126	168	210	252	294	336	378
422	42	84	126	168	211	253	295	337	379
423	42	84	126	169	211	253	296	338	380
424	42	84	127	169	212	254	296	339	381
425	42	85	127	170	212	255	297	340	382
426	42	85	127	170	213	255	298	340	383
427	42	85	128	170	213	256	298	341	384
428	42	85	128	171	214	256	299	342	385
429	42	85	128	171	214	257	300	343	386
430	43	86	129	172	215	258	301	344	387
431	43	86	129	172	215	258	301	344	387
432	43	86	129	172	216	259	302	345	388
433	43	86	129	173	216	259	303	346	389
434	43	86	130	173	217	260	304	347	390
435	43	87	130	174	217	261	304	348	391

The Uſe of the Table of Proportion, *for the more ready finding out of any* Logarithme, *from* 10000 *to* 100000.

WHen you have any *Logarithme* or Number above 10000, you may find it out as before, by the Differences which are in the laſt Column of the Tables: But for your more eaſie and ready performing it, this Table is of great uſe; wherein you have all thoſe Differences ready divided, and caſt into 10 parts: So that between each of the 10000 *Logarithmes* in the Table, you may eaſily know the ten Intermediate *Logarithmes*, by the Proportional Part of the Difference for any of them.

Thus in the Table the *Logarithme* of 2000 is	3.301029
The next *Logarithme*, being the *Logarithme* of 2001, is	3.301247

Alter the *Characteriſticks* of theſe *Logarithmes*,

So have you the *Logarithme* of 20000,	4.301029
And the *Logarithme* of 20010,	4.301247

The Difference between theſe two Numbers is 2185 which for the ten Intermediate *Logarithmes* muſt be divided into 10 Equal Parts, which is ready done in the Table of Proportion, after this manner.

D	1	2	3	4	5	6	7	8	9
218	31	63	95	127	159	190	222	254	286

So that the *Logarithme* of 20000 being	4.301029
The *Logarithme* of 20001, by adding 31, is	4.301060
The *Logarithme* of 20002, by adding 63, is	4.301092

And ſo for the reſt, to 20010.

Or, on the other ſide, Let your *Logarithme* given be 4.301251, and you deſire to know what Number anſwers to it; the next Number leſs in the Tables is 301029, which is the *Logarithme* of 20000: but this is 222 more, and the Common Difference in the Table is about 218; turn therefore to this Difference in the Table of Proportion, and there you ſhall ſee that 222 makes your Number 7 more: So that 4.301251 is the *Logarithme* of 20007.

And thus you ſave the Labour of multiplying and dividing the Differences in the Table of *Logarithmes*, they being here ready done to your hand.

FINIS.

A

SUMMARY

OF SUCH

PENALTIES and FORFEITURES

As are Limited and Appointed by ſeveral

ACTS

OF

PARLIAMENT

Relating to the

Cuſtoms & Navigation.

AS ALSO,

For the EXPORTING and IMPORTING of PROHIBITED GOODS.

TOGETHER WITH

The ſeveral STATUTES whereupon they are Grounded: Being duly Compared with the Statutes at Large, and the Abridgment to this preſent Year, 1664.

USEFUL FOR

Merchants, Factors, for all Officers belonging to the Cuſtoms, Maſters of Ships, Purſers, and Boatſwains, Mariners, Wharfingers, Lightermen, and Watermen.

In what caſe both Ship and Goods are Forfeited upon Importation.

LONDON,

Printed by *E. Cotes*, *Anno Domini* 1669.

SUMMARY

OF

ACTS

OF

PARLIAMENT

Relating to the

Customs & Navigation.

For the Exporting and Importing of

PROHIBITED GOODS.

The several Statutes whereupon they are Grounded: Being duly Compared with the Statutes at Large, and the Abridgment to this present Year, 1664.

Whereunto is Subjoyned, A Table of the Names, Factors, for all Officers belonging to the Customs, Waiters of Ships, Porters, and Boatswains, Mariners, Warrangers, Lightermen, and Watermen.

In what case both Ship and Goods are Forfeited upon Importation.

LONDON,

Printed by E. Cotes, Anno Domini 1669.

TO ALL

Merchants and Factors, and Commanders or Masters of Ships;

AND

To all other Officers and Mariners: And to all other Honest-minded Men whom this may Concern.

SAMUEL STURMY

Wisheth Prosperity, Courage, and Wisdom in all Your Lawful Undertakings.

GENTLEMEN,

FOR Your sakes I have inserted this following Abridgment or Summary of the Laws, and Penalties, and Forfeitures, as are limited and appointed by several Acts of Parliament, relating to the Customs and Navigation; and in what Cases both Ships and Goods are forfeited, upon Exporting or Importation of Prohibited Goods; together with the several Statutes whereupon they are grounded, being duly compared with the Statutes at large, and the Abridgment to 1664.

I have been provoked to annex this Summary of Custom-House Laws, the more out of a Principle of good will I have to you, and by knowing some of your defects, or want of knowledge in these

things, by my own in times paſt, when I was a Commander my ſelf. Through ignorance of theſe Laws your Goods have been ſeiſed and loſt, and Ships ſtopp'd and hindred in their Voyages, to the great loſs and damage of the Merchants, and Owners, and Mariners: Whereas if all concerned had but the knowledge of what they ſhould know, they might prevent this loſs and damage, and walk ſafely, without any detriment to themſelves or Goods, by the Officers; whereas otherwiſe, without this knowledge, your Ignorance is the Officers Advantage, and he will make you pay for it. And as I would adviſe every man to follow our Saviour's Counſel Matthew 22. 21. Render therefore unto Cæſar the things that are Cæſar's, and unto God the things which are God's: *as likewiſe* Rom. 13. 6, 7. Render therefore to all their dues, Tribute to whom Tribute is due, Cuſtom to whom Cuſtom, Fear to whom Fear, Honour to whom Honour: *So likewiſe I do adviſe all Officers to go diſcreetly on in their Buſineſs with all men, and not hinder, lett, or abuſe, in word or action, any one with whom they have Buſineſs, without juſt cauſe; nor thoſe that fall into their Hands; nor to take the juſt rigour of the Law of* England, *leſt the Univerſal God ſhould take the Law of Heaven upon us for our Errors and Failings: but take reaſonable Satisfaction. This is my advice to both Merchants and Officers, and all others concerned. I am their Well-wiſher, and ſo remain to be,*

Pill, 1 Septemb. 2. 1667.

SAMUEL STURMY.

A SUMMARY OF SUCH PENALTIES and FORFEITURES

As are Limited and Appointed by Several

ACTS of PARLIAMENT

Relating to the

CUSTOMS and NAVIGATION.

First, ALL manner of Goods Imported into his Majesties Plantations, or Exported out of his Majesties Plantations, in Forreign Shipping, both Ship and Goods are forfeited. *Vide Statute of Navigation*, 12 *Caroli* 2. 18.

Secondly, All Goods that are of the growth of *Asia*, *Africa*, and *America*, Imported in Forreign Shipping, are forfeit, *per id. Stat.*

Thirdly, All Goods of the growth, production, and manufacture of *Asia*, *Africa*, and *America*, shall be Imported from the place of their growth, production, or manufacture; otherwise both Ship and Goods are forfeited, *per id. Stat.*

Except the Goods of the *Spanish* Plantations may be brought from *Spain*, and the Goods of the *Portugal* Plantations may be brought from *Portugal*, and *East India* Commodities may be brought from any Port on the Southward or Eastward of *Cape Bona Speranza*, and the Commodities of the *Levant* Seas may be brought from any Port within the *Straights*; Provided that all these Goods may be Imported in *English* Shipping, otherwise both Ship and Goods are forfeited, *per id. Stat.*

Fourthly, All Goods of Forreign growth, production, or manufacture, shall be Imported from the place of their growth, production, or manufacture, or from such place where they are usually first Shipp'd for Transportation only, and only in *English* Ships, or in Ships truly belonging to such place where such Goods are lawful to be Shipped; otherwise both Ship and Goods are forfeited, *per id. Stat.*

In this Case a Dutch Ship called the Grass Mower, laden with Salt and Brandy, was seised by us, for bringing Goods from Rochel *to a* Bristol *Merchant; and the Ship and Goods was bought again for* 220*l. by a Letter of Licence.*

Fifthly, All Goods carried from Port to Port (in *England*, *Ireland*, *Wales*, or *Berwick*) in Forreign Shipping, whereof the Owners or Part-owners are not all *English*, as also the Master and three fourths of the Mariners, both Ship and Goods are forfeited, *per id. Stat.*

Sixthly, All Goods of the growth, production, or manufacture of any of his Majesties Plantations, shall be first landed in *England*, *Ireland*, *Wales*, or *Berwick*, before they can be transported; otherwise both Ship and Goods are forfeited, *per id. Stat.*

Seventhly,

Seventhly, All manner of Wines, except *Rhenish*; all Spicery and Grocery, Tobacco, Pot-aſhes, Pitch, Tar, Roſin, Salt, Deal Boards, Fir Timber, or Olive Oyl, that ſhall be imported from the *Netherlands* or *Germany*, are forfeited, as alſo the Ship in which they are imported. *Vide Stat.* 14 *Car.* 2. 11. intituled, *An Act to prevent Frauds*, &c. *in his Majeſties Cuſtoms.*

Eighthly, All Freſh Herrings, Freſh Cod or Haddock, Cole-fiſh or Gul-fiſh, that ſhall be Imported into *England* or *Wales* in Forreign Shipping, both Ship and Goods are forfeited. *Vide Stat.* 15 *Car.* 2. 7. intituled, *An Act for Encouraging of Trade.*

Goods forfeited for being Imported into England or Wales, without any Penalty upon the Ship; theſe Goods being all Engliſh *Manufactures.*

Tin and Pewter ALL manner of Tin and Pewter Manufactures made in Forreign Parts are forfeited. *Vide Stat.* 25 *Hen.* 8. 14.

Braſs. Officers may ſearch and ſeiſe Wares brought into the Realm contrary to the ſaid Act, and none ſhall withſtand the ſearch of Braſs, Tin, and Pewter, on the forfeit of five pounds, *per id. Stat.*

Several Commodities forfeited. Woolen Clothes, Woolen Caps, Ribbons, Fringes of Silk and of Thred, Laces of Silk and of Thred, Silk Twine, Embroidered Laces of Silk or Gold, Saddles, Stirrops, or any Harneſs belonging to Saddles, Spurs, Boſſes for Bridles, Andirons, Gridirons, any manner of Locks, Hammers, Pincers, Fire-tongs, Dripping-pans, Dice, Tennis-balls, Points, Purſes, Girdles, Gloves, Harneſs for Girdles, Iron, Latten, Steel, Tin, or Alchymy, or any Wrought or any Tawed Leather, any Tawed Furs, Biskin Shoos, Galloſhes, or Cork, Knives, Daggers, Wood-knives, Bodkins, Sheers for Taylors, Sciſſors, Razors, Cheſs-men, Playing Cards, Combs, Pattens, Pack-needles, any Painted Wares, Forſers, Caskets, Rings of Copper or of Latten, guilt Chafingdiſhes, Hanging Candleſticks, Caffing Balls, Sacring Bells, Rings for Curtains, Ladles, Scummers, counterfeit Baſons, Ewers, Hats, and Bruſhes, Cards for Wooll, black Iron, Thred called Iron Wyre, or whited Wyre, are forfeited if any ſuch be Imported into *England* or *Wales*. *Vide Stat.* 4 *Edw.* 4.

Prohibited Goods forfeited. All Iron Wyre, Card-wyre, or Wool-cards, that ſhall be Imported into *England* or *Wales*, are forfeited. *per Stat.* 39 *Eliz.* 14. 14 *Car.* 2. 19.

Prohibited more forfeited. All manner of Girdles, Harneſs for Girdles, Points, Leather, Laces, Purſes, Pouches, Pins, Gloves, Knives, Hangers, Taylors Sheers, Sciſſors, Andirons, Cobbards, Tongs, Fire-locks, Gridirons, Stock-locks, Keys, Hinges and Garnets, Spurs, painted Glaſſes, painted Papers, painted Forcers, painted Images, painted Clothes, beaten Gold or Silver wrought in Papers for Painters, Saddles, Saddle-trees, Horſe-Harneſs, Boots, Bits, Stirrops, Chains, Buckles, Latten Nails with Iron Shanks, Curvets, Hanging-candleſticks, Holy-water, Stops, Chafing-diſhes, Hanging Lavers, Curtain-rings, Cards for Wool, *Roan* Cards, Sheers, Buckles for Shoos, Broaches for Spits, Belts, Hawk-bells, Tin and Leaden Spoons, Wyre of Latten and Iron, Candleſticks, Grates, Horns for Lanthorns, or any of theſe, being Imported into *England*, are forfeited, or the value thereof, betwixt the King and the Proſecutor. Theſe may be ſued for in any Corporation where they are. *Vide Stat.* 1 *R.* 3. 12.

All Girdles, Harneſs for Girdles, Rapiers, Daggers, Knives, Hilts, Pummels, Lockets, Blades, Handles, Scabbards, Sheaths for Knives, Saddles, Horſe-Harneſs, Stirrops,

Stirrops, Bits, Gloves, or Points, Leather Laces, or Pins, that ſhall be Imported into *England* or *Wales*, ſhall be forfeit. 5 *Eliz.* 7. *Goods prohibited.*

All manner of Silk wrought by it ſelf, or with any other Stuff, in any place out of the Realm, Ribbons, Laces, Girdles, Corſes called Corſes of Tiſſue, or Points, ſhall be forfeited, *per Stat.* 19 *Hen.* 7. 21.

All Forreign Bone-lace, Cut-work, Fringe, Embroidery, Bandſtrings, Buttons, or Needle work, made of Silk or Thred, or either of them, being Imported into *England*, *Wales*, or *Berwick*, ſhall be forfeited, beſides the Forfeiture of one hundred pound. 14 *Car.* 2. 13. *Goods prohibited* 100 *l.*

All manner of Woollen Cloth that ſhall be Imported into *England*, *Ireland*, or *Wales*, from beyond the Sea, ſhall be forfeited. *Vide Stat.* 2 *Edw.* 3. 3. & 4 *Ed.* 4. 1.

In what Caſes Goods are forfeited for Undue Shipping or Landing.

ALL Goods that ſhall be Shipped or Landed before the Cuſtom paid or agreed for in the Cuſtom-houſe, are forfeited. *Tide Stat.* 12 *Car.* 2. 4. intituled, *The Act for the Tonnage and Poundage.* *Goods ſhipp'd or landed before Cuſtom paid are forfeit.*

All Goods that ſhall be Shipped or Landed, or put into any other Veſſel to be Shipped or Landed, at any unlawful time or place, are forfeit, or the value of them. 1 *Eliz.* 2. & 14 *Car.* 2. 11. *Unlawful time or place loſe.*

All Goods that ſhall be put into any Lighter, Boat, or any other Veſſel, to be Shipped or Landed, without Warrant from the Cuſtom-houſe, and the preſence of one or more Cuſtom-houſe Officer, are forfeited, as alſo the Lighter or other Veſſel in which they are found to be Shipped or Landed. *Vide Stat.* 14 *Car.* 2. 11.

If any Maſter of Ship, Purſer, Boatſwain, or other Mariner, knowing or conſenting to the diſcharge of Goods inward bound, without Warrant from the Cuſtom-houſe, or the preſence of one or more Cuſtom-houſe Officer, ſhall forfeit the value of the ſaid Goods ſo unſhipped. *Vide Stat.* 14 *Car.* 2. 11. *Perſons conſenting to the diſcharge of Goods inward bound without Warrant, the penalty.*

Every Cuſtomer, Collector, and Comptroller, that doth conceal his Majeſties Cuſtoms; being duly Entred, ſhall forfeit treble the value thereof, *per Stat.* 3 *H.* 6. 3. *Officers concealing Cuſtom, the penalty.*

If any Goods having paid Cuſtom at the Importation, and ought to have allowance at the Exportation; if the Merchant Ship out leſs in quantity than is expreſſed in his Certificate, ſhall be forfeited, or the value of them. 14 *Car.* 2. 11. *The penalty to ſhip out leſs than is expreſſed.*

If the ſaid Goods be Landed again in *England*, *Wales*, or *Berwick*, except they be made known in the Cuſtom-houſe, ſhall be forfeit, *per id. Stat.* *Landing Goods, unleſs made known in Cuſtom-houſe, forfeited.*

If any Goods be put on board a Ship to be carried from Port to Port, without Warrant from the Cuſtom-houſe, all ſuch Goods ſhall be forfeit, *per id. Stat.* *Goods carried from Port to Port without Warrant forfeited.*

If the true content of Quantity and Quality be not mentioned in the Certificate, under the Cuſtomers Hand in the Port where they are Shipped firſt to paſs for another Port, all ſuch Goods not certified or diſcharged before the ſaid Certificate delivered, and the Goods viewed, ſhall be forfeit, *per Stat.* 3 *H.* 7. 7. *Quantity and quality muſt be expreſſed.*

Quere, Whether this Statute be in force or not?

All

Goods exported, and not diſcovered unto the Officer, forfeit double the value.

All manner of Goods, Wares, or Merchandize, that ſhall be Exported, and eſcape undiſcovered unto the Officers of the Cuſtoms, the Owner or Proprietor ſhall forfeit double the Value, according to the *Book of Rates*; Except for Coals, for which they ſhall forfeit double the Cuſtom. *Vide Stat.* 14 *Car.* 2.

England and Scotland, Goods that paſs.

All Goods, Wares, and Merchandize, that ſhall paſs by Land betwixt *England* and *Scotland*, ſhall paſs by and through *Berwick* and *Carliſle*, and pay Cuſtom at one of thoſe Ports, otherwiſe be forfeited, *per Stat.* 14 *Car.* 2. 11.

In what Caſes Ship and Goods are forfeited upon Exportation of Goods.

Licence to be granted for Paſſengers to paſs beyond the Sea.

IF any Woman, or other perſon under the Age of twenty one years, except Shipboys, Sailors, or Merchants Apprentices, or Factors, ſhall paſs over the Sea, without Licence from the King, or 6 of the Privy Council, the Ship in which ſuch Perſon ſhall ſo paſs ſhall be forfeit. *Vide Stat.* 1 *Jac.* 4.

Leather, Tallow, &c.

If any Perſon ſhall Tranſport, or Ship to be Tranſported, Leather, Tallow, or Raw Hides, to any Place beyond the Sea, all ſuch Goods ſhall be forfeit, as alſo the Ship wherein they are Exported. *Vide Stat.* 18 *Eliz.* 9.

Hoys or Plats, &c.

If any Hoy or Plat croſs the Seas beyond *Norway* Eaſtward, or *Caen* in *Normandy* Southward, they ſhall be forfeit. *Vide Stat.* 1 *Eliz.* 13. 5 *Eliz.* 5. 13 *Eliz.* 15.

Corn or Victual.

If any Corn, or other Victual, be Tranſported, exceeding the Prices mentioned in the *Act for Encouraging of Trade*; or if any Wood ſhall be Traſported, they ſhall forfeit the Veſſel in which it ſhall be Exported, and alſo double the value of the Goods. *Vide Stat.* 1, 2 *Phil. & Mar.* 5. the Maſters and Mariners all their Goods, and a years Impriſonment.

Engliſh Manufactures to be exported in Engliſh Shipping.

If any Goods of the growth, production, or manufacture of *Europe* be tranſported into his Majeſties Plantations, except from *England*, and in *Engliſh* built Shipping, both Ship and Goods are forfeited. *Vide Stat.* 15 *Car.* 2. 5.

Due entry to be made in 24 ho.

If the Maſter ſhall ſuffer any Goods to be Landed before a due Entry made within twenty four Hours after arrival in the ſaid Plantations, both Ship and Goods are forfeited, *per id. Stat.*

Ships for fiſhing, the time to ſet out.

If any Ship ſhall ſet out to Fiſhing, or other Veſſel ſhall ſet out for the Weſt Country or *Iſeland* Fiſhing, before the tenth day of *March* in any Year, ſuch Veſſel ſhall be forfeit. *Vide Stat.* 15 *Car.* 2. 14. intituled, *An Act for the Fiſhing Trade.*

Sheep, Wool, &c.

If any Sheep or Wooll, Wooll-fells, Wooll-flocks, Mortlings, Shorlings, Yarn made of Wooll, Fullers Earth, Fulling Clay, ſhall be Exported, all ſuch Goods are forfeit, as alſo the Ship wherein they are Exported. *Vide Stat.* 12 *Car.* 2. 32.

Silver & Gold, &c.

If any Silver or Gold be Exported without Licence, it ſhall be forfeited. *Vide Stat.* 5 *R.* 2. 2. *& 9 Edw.* 3. 1. *& 2 Hen.* 4. 5. *& 2 Hen.* 6. 6.

None but Merchant Strangers ſhall Tranſport Wooll, Wooll-fells, Leather, and Lead beyond the Seas, upon the Forfeiture of the ſaid Goods. *Vide Stat.* 27 *Ed.* 3. 3. 14 *Rich.* 2. 5.

If

If any Skin, tann'd or untann'd, of any Ox, Steer, Bull, Cow, or Calf (except Calve-skins of four pound weight apiece, or under) and Sheeps Skins dreſſed without the Wooll of ſuch Skins or Hides, which are for the Ships neceſſary Proviſion, ſhall paſs out of *England* beyond the Seas, or into *Ireland* or *Scotland*, or the Iſlands belonging to *England*, ſhall be forfeited. *Vide Stat.* 14 *Car.* 2. 7. *Skins tann'd or untann'd.*

If any of the Hides or Skins aforeſaid, that ſhall be taken off of any Beaſt in any of the Iſlands belonging to *England*, except *Ireland*, ſhall be Tranſported into any Place except *England*, the Offender ſhall forfeit double the value for every Offence, *per id. Stat.* *Hides tranſported, except from* Ireland, *the penalty.*

All manner of Ammunition may be prohibited at his Majeſties pleaſure. 12 *Car.* 2. 4. *Ammunition may be prohibited.*

If any Sheep ſhall be Exported, the Offender ſhall forfeit 20 *s.* for every Sheep. *Vide* 12 *Car.* 2. 32. *Sheep exported, the penalty.*

If any Wooll, Wooll-fells, Wooll-flocks, Mortlings, Shorlings, Yarn made of Wooll, Fullers Earth, Fulling Clay, ſhall be ſhipp'd to be Exported, the Offender ſhall forfeit three ſhillings for every pound weight. *Fullers Earth & Fulling clay.*

If any Maſter of a Ship, or other Mariner, be knowing and conſenting to the Exportation of the Goods aforeſaid, he ſhall forfeit all his Goods and Chattels, *per idem Stat.* *The penalty of giving conſent to the ſhipping of the ſaid Goods.*

Theſe Offences are alſo made Felony *per Stat.* 13, 14 *Car.* 2. 18. except ſuch Weather-ſheep, Wooll, or Wooll-flocks, as are for neceſſary proportion for the Ships uſe. *Felony to export Sheep.*

If any Wooll, Wooll flocks, or Yarn made of Wooll, ſhall be preſſed with any Engine into any Sack, Pack, or other Wrapper, or ſhall put, preſs, or ſteeve Wooll or Woollen Yarn into any Pipe, But, or Hogſhead, Cheſt, or other Cask or Veſſel, or carry or lay any ſuch Wooll, Wooll-flocks, or Yarn made of Wooll, neer to the Sea or any Navigable River, all ſuch Wooll, Wooll-flocks, and Yarn made of Wooll, ſhall be forfeited. *Vide Stat.* 13 & 14 *Car.* 2. 18. *Wooll, &c. preſt with any Engine, &c. penalty.*

If any Wooll, Wooll-fells, Mortlings, Shorlings, Yarn made of Wooll, Wooll-flocks, Fullers-Earth, Fulling-clay, or Tobaccopipe-clay, being in any Pack, Sack, Bag, or Cask, ſhall be carried upon any Horſe, Cart, or other Carriage, except in the day time, *viz.* from the firſt of *March* to the twenty ninth of *September* betwixt the Hours of four in the morning and eight at night, and from the twenty ninth of *September* until the firſt of *March* between the Hours of ſeven in the morning and five at night, otherwiſe to be forfeited, *per id. Stat.* *Fullers earth, &c. Tobacco-pipe clay.*

If any Tobaccopipe-clay be Exported beyond the Sea, the Officer ſhall forfeit three ſhillings for every pound weight, *per id. Stat.* *Tobacco pipe clay.*

If any manner of Sheep-skins, Wooll-fells, Mortlings, Shorlings, or the Skins of any Stag, Buck, Hind, Doe, Goat, Fawn, or Kid, or the Pelts or Skins of any of them, or the Leather made of any of them, be put on board any Veſſel to be exported, they ſhall be forfeited, as alſo two ſhillings ſix pence for every Fell, Shorling, Mortling, Pelt, or Skin, ſo Shipped to be Exported. *Vide Stat.* 5 *Eliz.* 22. *Sheep ſkins, or the Leather, &c. penalty.*

All great Cattel, except of *Scotland*, that ſhall be Imported into *England* or *Wales* betwixt the firſt of *July* and the twentieth of *September* in any year; and all great Cattel of *Scotland* that ſhall be brought in betwixt the twenty fourth of *Auguſt* and the twentieth of *December* in any year, ſhall forfeit for every Head forty *Great Cattel imported, the penalty.*

ſhillings; and for every Sheep brought in betwixt the one and twentieth of *Auguſt* and twentieth of *December*, ten ſhillings, *per Stat.* 15 *Car.* 2. 5.

Goods entred in another mans name. If any Goods be entered in any other mans Name than the true Owner and Proprietor, they ſhall be forfeit: And if the Officer conceal any Offence in the ſaid Act, he ſhall forfeit one hundred pounds. *Vide Stat.* 1 *Eliz.* 11.

Priſage and Butlerage of Wines. If any man, being free of the Priſage or Butlerage of Wine, ſhall Enter another mans Wines in his Name, whereby the King loſeth his Butlerage, all Wines ſo Entred are to forfeit double the value of the Cuſtoms thereof. *Vide* 1 *Hen.* 8. 5.

If any man offend contrary to the *Stat.* 1 *Hen.* 8. 5. he ſhall forfeit all his Goods. *Vide Stat.* 2 *&* 3 *Edw.* 6. 22.

Sugar, Tobacco, Ginger. If any Officer of the Cuſtoms ſhall ſuffer or give any Warrant for any Sugar, Tobacco, Ginger, Cotton-wooll, Indico, Speckle-wood, *Jamaica*-wood, Fuſtick, or any other Dying-wood, of the growth of any of his Majeſties Plantations, to be conveyed into any Parts beyond the Seas, before they are Landed in *England* or *Wales*, for every Offence he ſhall forfeit the value of the ſaid Goods. *Vide Stat.* 15 *Car.* 2. 5.

Goods of Alien Merchants. All the Goods of an Alien Merchant or Factor in any of his Majeſties Plantations are forfeited. *Vide Stat.* 12 *Car.* 2. 18.

Copper, Braſs, Bell-mettle, &c. If any manner of Copper, Braſs, Latten, Bell-mettle, Pan-mettle, Gun-mettle, or Shroof-mettle, ſhall be put on board any Veſſel to be tranſported, the Offender ſhall forfeit double the value, to be divided betwixt the King and the Proſecutor. *Vide Stat.* 33 *Hen.* 8. 7.

10 l. penalty. And alſo ten pounds more for every thouſand pound weight, *per Stat.* 2 *&* 3 *Edw.* 6. 37.

The Cuſtomer not performing duty, the penalty. The Cuſtomer ſhall take Bond in double the value of the ſaid Goods, when they ſhall be tranſported from Port to Port, and alſo 10 *l.* over and above for every thouſand pounds weight, and give Bond; which Bond, if it want a Date, the Cuſtomer ſhall forfeit the value of the ſaid Goods, and alſo his Place, *per id. Stat.*

To grant a falſe Certificate, the penalty. If any Cuſtomer grant a falſe Certificate for the ſaid Goods, he ſhall forfeit his Place, and the value of the Goods ſo concealed. 33 *Hen.* 8. 7.

The penalty of the not diſcovering. If any Maſter of a Ship, Owner, Purſer, or Boatſwain, knowing ſuch Mettles to be Shipp'd, and do not diſcloſe it within three days, he ſhall forfeit double the value of it. *Vide Stat.* 2 *&* 3 *Edw.* 6. 37.

Not ſeiſing the ſaid Goods, the penalty. If any Officer of the Cuſtom-houſe, knowing ſuch Mettles to be Shipp'd to be Tranſported, do not ſeiſe it, he ſhall loſe his Office, and the value of the Goods ſo Shipp'd. *Vide Stat.* 2 *&* 3 *Edw.* 6. 37.

The ſaid Goods not to be ſhipp'd but where there is a Cuſtomer. If any Perſon Ship any of the ſaid Mettles at any Place, except where there is a Cuſtomer, he ſhall forfeit the value of the Goods, and alſo ten pounds for every 1000 pounds weight, *per id. Stat.*

Penalty 1000 *l. to a Governour not doing his duty.* If the Governour of any Plantation belonging to his Majeſty, do not his duty juſtly, according to the *Act for Encouragement of Trade*, he ſhall forfeit his Place and 1000 *l. per Stat.* 15 *Car.* 2. 15.

Tranſporting Leather. Every Perſon that ſhall be found guilty of Tranſporting of Leather, ſhall for every Offence forfeit 500 *l. Vide Stat.* 14 *Car.* 2. 7.

Every

Every Cuſtomer, or other Officer, that ſhall neglect his duty, or connive at the Tranſportation of Leather, ſhall for every Offence forfeit 100 pounds. *Vide Stat.* 1 *Jac.* 22. *Officer neglecting his duty, penalty* 100 *l.*

Every Cuſtomer, or other Officer, that ſhall make a falſe Certificate of the Landing of Leather, ſhall forfeit 100 *l. per id. Stat.* *To make falſe Certificates of landing Leather, penalty* 100 *l.*

If any Goods or Merchandiſe ſhall be Shipp'd or Landed at any unlawful time or place, for every Offence the Maſter, Owner, or Purſer ſhall forfeit 100 *l.* 1 *Eliz.* 11. & 14 *Car.* 2. 11. *Goods ſhipp'd at any unlawful hour, the penalty* 100 *l.*

Lawful times are only from the firſt of March *until the firſt of* September, *betwixt Sun-riſing and Sun-ſetting; and from the firſt of* September *until the firſt of* March *betwixt ſeven a clock in the Morning, and four a clock in the afternoon. The Port of* Hull *is here excepted.* *What lawful times are by Order.*

If the Captain, Maſter of a Ship, or Purſer outward bound, ſhall take in any Goods before Entry, he ſhall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. 11. *Goods taken in before entry made* 100 *l.*

If he go away before cleared on Oath in the Cuſtom-houſe, giving a true Accompt of his Lading, &c. he ſhall forfeit 100 *l. per id. Stat.* *To go before cleared on Oath, penalty* 100 *l.*

If any Captain, Maſter of a Ship, or Purſer, do not bring his Ship to the Port, and make Entry with as much ſpeed as Wind and Water will permit, for every Offence he ſhall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. *Maſter of Ship to bring his Ship with as much convenience, &c.*

If he permit any Goods to be taken out of the Ship, to be Landed, before he hath made his general Entry upon Oath in the Cuſtom-houſe, for every Offence he ſhall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11. *To ſuffer Goods taken out before a general entry, penalty* 100 *l.*

If any Captain, Maſter of a Ship, Purſer, or Boat-ſwain, or other Perſon taking Charge of the Ship, ſhall permit any ſort of the Package therein to be opened, imbezeled, or altered, for every Offence he ſhall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. 11. *Goods imbezeled, &c.* 100 *l.*

Men of War to be liable to the Rules that Merchant Ships are ſubject to. Liberty to go on board and take out Prohibited and Uncuſtomed Goods. The Commiſſioners and their Deputies to enter on board, and bring on ſhore Goods outward and inward bound. The Officers may ſtay on board until the Goods be diſcharged. 14 *Car.* 2.

If any Goods be found concealed aboard the Ship, when the Officers of the Cuſtoms have cleared the Ship, the Maſter, or other Perſon, ſhall for every Offence forfeit 100 *l. per id. Stat.* *Goods concealed* 100 *l.*

If any Wharfinger, Crane-keeper, Searcher, Lighterman, or other Officer, knowing any Offence contrary to the Statute, do not diſcloſe it to the Cuſtomer, he ſhall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11. *Wharfinger, &c. not diſcloſing, &c. penalty* 100 *l.*

If any Wharfinger or Crane-keeper ſhall take up or Land, or ſuffer to be Landed, or Ship off, or ſuffer to be Water-bound, any Wares or Merchandiſes, at any unlawful time, or without the preſence of, or notice given to an Officer at the Cuſtom-houſe, he ſhall forfeit for every Offence 100 *l. per Stat.* 14 *Car.* 2. 11. The Port of *Hull* excepted. *To ſuffer Goods to be taken up or landed at unlawful times.*

100 l. penalty for taking of Bribes. If any Officers of the Customs shall directly or indirectly receive any Bribe, Recompense, or Reward, or shall connive at any false Entry of Goods, he shall forfeit 100 *l. per id. Stat.*

50 l. penalty to give a Bribe. If any Merchant, or other Person, shall give such Bribes, for every Offence he shall forfeit 50 *l. per id. Stat.*

100 l. If any Packet Boat, or other Vessel appointed to carry Letters, shall Import or Export any Goods or Merchandise, for every Offence the Master shall forfeit 100 *l. per id. Stat.*

Forreign Bone-lace, Cut-work penalty 50 l. If any Person offer to sale any Forreign Bone-lace, Cut-work, Imbroidery, Fringe, or Needle-work made of Silk or Thred, for every Offence he shall forfeit 50 *l. per id. Stat.*

100 l. If any of the said Goods be Imported into *England* or *Wales*, the Offender shall forfeit 100 *l. per id. Stat.*

False Certificate, penalty 50 l. If any Officer of any Port shall make a false Certificate, he shall forfeit 50 *l. per id. Stat.*

To falsifie any Warrant 100 l. If any Person shall falsifie any Custom-house Warrant, he shall forfeit for every Offence 100 *l. per id. Stat.*

The Officer to make a true report, on penalty of 100 l. Every Officer appointed to perfect an Entry, shall make report thereof under his Hand, unto the Chief Officers of the Customs, the next day, upon the Penalty of 100 *l.* unless there be cause of longer time to be allowed by the Chief Officers of the Customs, *per id. Stat.*

French Vessels not to put Goods on shore, not paying 5 s. per Tun, the penalty 10 l. If any *French* Vessel put any Goods or Passengers on Shore, or into any Boat, to be conveyed on Shore, and not pay the five shillings *per* Tonnage due upon *French* Vessels, upon their return they shall forfeit ten pounds, and pay all the former Duty, *per id. Stat.*

Pilot or Waterman going out of any Port brings Goods, &c. penalty 40 l. If any Pilot or Waterman shall go out from any Port, to bring in any Goods or Passengers from aboard of any *French* Vessels, for every Offence he shall forfeit 40 *l. per id. Stat.*

Officers not giving attendance, penalty 100 l. If any Customer, Comptroller, or Searcher, or their Deputies, do not give their attendance at the Custom house at such time and places as are appointed by Law, and also do not their utmost diligence in their respective Places, for every Offence the Offender shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11.

Not resident on his Place, penalty 100 l. If any Customer, Comptroller, or Searcher be not resident upon his Place and Office, for every Offence he shall forfeit 100 *l. Vide Stat.* 1 *Hen.* 4. 13. 4 *Hen.* 4. 20, & 21. 13 *Hen.* 4. 5.

No Custom Officer to be Owner of a Ship, or use Merchandise, &c. penalty 40 l. If any Custom-house Officer fraight any Ship, or use any Merchandise, or keep any Wharfe, or hold any Hostery, or Tavern, or be Factor, or Attorney, or Host to any Merchant, for every Offence he shall forfeit 40 *l.* for every six Months, to be divided betwixt the King and the Prosecutor. *Vide Stat.* 20 *Hen.* 6. 5.

If

If any Customer, Comptroller, or Searcher, be a Common Officer, or Deputy to a Common Officer, in any City, Burrough, or Town, upon the penalty of 40 *l.* for every six Months he shall so officiate both Offices together. *Vide Stat.* 3 *Hen.* 7. 1. *No Custom Officer to be a common Officer, penalty* 40 *l.*

Quere, Whether this Statute be in force, or Repealed by the Statute of 1 Hen. 8. 5.

English Shipping is either *English* built, or bought *bona fide* by *English* Money, whereof every Owner or Part-owner are *English*, *Irish*, *Welch*, or of his Majesties Plantations. *English-built shipping, what is meant.*

A TABLE

A TABLE OF THE STATUTES

Relating to the

CUSTOMS, and NAVIGATION, and TRADE,

Made in the Reign of

King *CHARLES* the Second.

Tonnage and Poundage ——— 12 *Car.* II. 4.

Preventing Frauds ——— 14 *Car.* II. 11.

Navigation Encouraged ——— 12 *Car.* II. 18.

Wooll, Sheep, &c. ——— 12 *Car.* II. 32.

Leather, &c. ——— 14 *Car.* II. 7.

Bonelace, &c. ——— 14 *Car.* II. 13.

Wooll-fells, &c. ——— 14 *Car.* II. 18.

Card-Wyre and *Iron Wyre*, &c. ——— 14 *Car.* II. 19.

Encouragement of Trade, &c. ——— 15 *Car.* II. 5.

Encouragement of Fiſhing ——— 15 *Car.* II. 14.

THE

THE AUTHOR TO His Books.

SInce now, my Book, thou art ſo far gone on,
Abroad on Gods Name, and be better known:
But had there been now but one quarter done,
That, nor the reſt, ſhould n'er have ſeen the Sun.
To Friends be free, ope them thy Treaſures Store:
But carping Scoffers, let them have no more
But Scraps; for that's enough, and good for ſuch
As poyſon all they ſee, foul all they touch,
And on Mechanick Scapes forge Arts detraction,
Ere they will wink, or mend the faultier action
Th' Errata's made. I never did intend it
For ſuch as not commend, nor can come mend it;
Not I: And ſo I end it.

ERRATA.

TO

HIS BOOKS.

A COMPENDIUM OF FORTIFICATION,

BOTH

Geometrically and Instrumentally,

BY A

SCALE,

The Making whereof is shewed by the Tables, and their Use, both of the Tables and the Scale, for speedy Protracting of any Fort consisting of 8 Bulwarks, whose Bastion-Angles shall not exceed 90 Degrees; and so the like for Bastion-Angles of 12 Bulwarks.

WRITTEN BY

PHILIP STAYNRED

Professor and Teacher of the MATHEMATICKS in the City of BRISTOL.

JER. XVI. 19.

The Lord is my strength, and my fortress, and my refuge in the day of affliction.

LONDON,

Printed by *E. Cotes*, *Anno Domini* 1669.

COMPENDIUM
OF
FORTIFICATION,
BOTH
Geometrically and Instrumentally
BY A
SCALE.

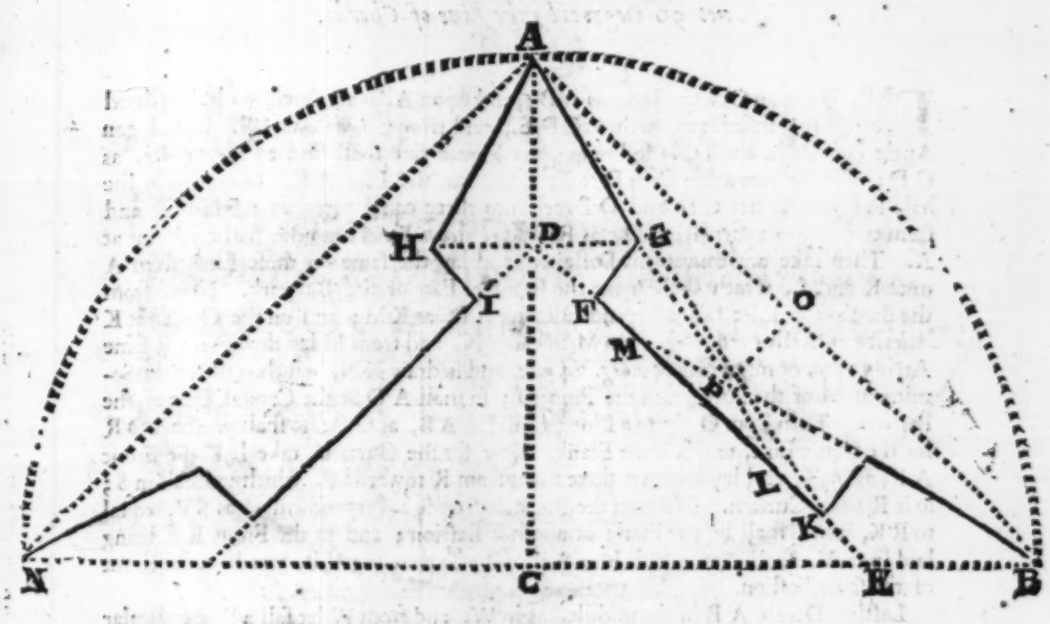
The Making whereof is shewed by the Tables, and their Use, both of the Tables and the Scale, for speedy Protracting of any Plan containing of Bulwarks, whose Angles exceed 90 Degrees; and of the Rules for Setting out

Professor and Teacher

98:88:84

A COMPENDIUM OF FORTIFICATION.

FIrſt, I will deſcribe part of a Tetragon or Square Fort, and explain the Names of the Sides and Angles thereof, as in the Figure following.



Names of the Sides of a Fort.

A B the Outward Side of the Polygon, and D E the Inward Side.
C A the Semidiameter of the Outward Polygon, and C D the Inward.
I H A G F the Bulwark or Baſtion.
A G, or A H, the Front or Face of the Baſtion ——— 280 *Feet.*
A D the Capital or Head Line,
D I, or D F, the Gorge Line.
I H, or F G, the Flank; and F M the ſecond Flank.
D G the Eſpaule, or Shoulder.
F K the Curtain ——— 420 *Feet.*
A K the longeſt Line of Defence ——— 720 *Feet.*
A L the ſhorteſt Line of Defence.

Names of the Angles.

N A B the Angle of the Polygon, and N A C the half Angle.
H A G the Flanked Angle of the Bulwark.

 A G F

A G F the Angle of the Shoulder.
F D G the Angle forming the Flank, commonly 40 Degrees.
G A O the Inward Flanking Angle.
A P B the Outward Flanking Angle, and A P O half the ſame.

Note, That the Baſtion or Flanked Angle H A G muſt never be leſs than 60 Degrees, neither above 90 Degrees; but as neer as you can to an Angle of 90 Degrees: So that it may be defended from the Flank and Curtain on either ſide.

The longeſt Line of Defence K A not to be above 12 ſcore Yards, that is, 720 Foot, being within Musket-ſhot; and the breadth of the Rampire to reſiſt the Battery 100 Foot.

To Deſcribe a Fort of Five Bulwarks, or any other; ſo that the Baſtion, or Flanked Angle of 8 Baſtions or Bulwarks exceed not 90 Degrees by the Line of Chords.

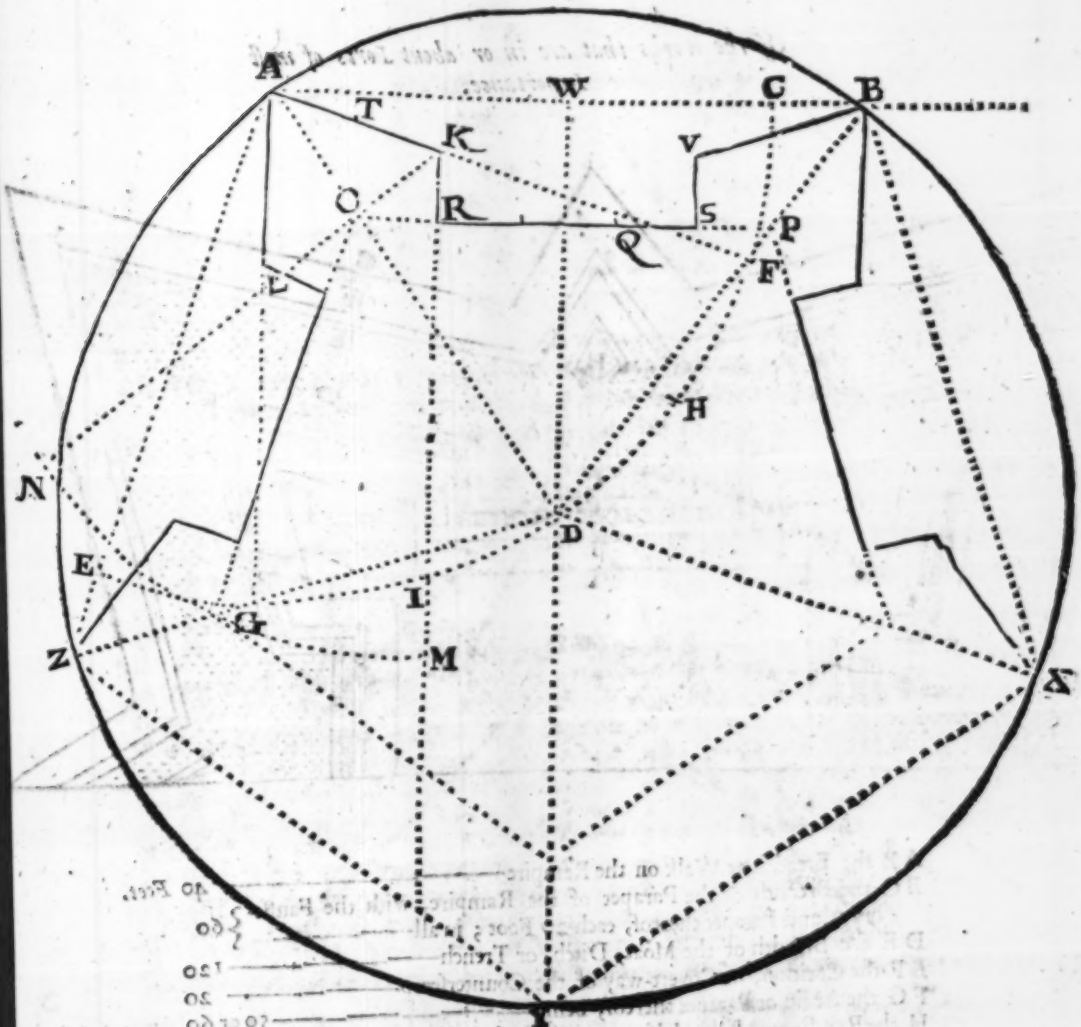
FIrſt, Draw an Obſcure Line, as A B; and upon A, as a Center, with the Chord of 60 *deg.* deſcribe an Arch, as C D E; and from C lay down half the Polygon Angle (which in the Table following the Figure you ſhall find to be) 54 *deg.* as C D; alſo the ſame again from D to E, and draw the Line A E. Now divide the half Polygon Arches C D and D E each into three equal parts, as in F H I G, and from two of thoſe parts from D, as F and G, draw Lines unto the Baſtion Point at A. Then take any convenient Diſtance, and lay the ſame on thoſe Lines from A unto K and L, which ſhall make the Front or Face of the Bulwark. Next, from the ſhoulder at K let fall a Perpendicular to A B, as K M; and on the Center at K deſcribe an Arch of 60 *deg.* from M towards N, and from M lay down on the ſame Arch 50 *deg.* or more exact 49 *deg.* 24 *min.* and ſo draw K N, which will cut the Semidiameter of the Polygon in the Point O; ſo ſhall A O be the Capital Line of the Baſtion. Then from O draw a Line parallel to A B, as O P; ſo ſhall you have O R for the Gorge Line, and R K the Flank. Now for the Curtain, take half the Front A K, as A T, and lay it down three times from R towards P, which will fall in S; ſo is R S the Curtain. Then on the Point at S erect a Perpendicular, as S V, equal to R K, which ſhall be the Flank of another Baſtion; and ſo the Front K A being laid from V, ſhall cut the firſt Line A B in B; ſo drawing V B, you have the Front of the ſame Baſtion.

Laſtly, Divide A B in the middle, as in W, and from W let fall a Perpendicular to A B, which will cut the Semidiameter of the Polygon in the Point D; ſo is D the Center of the Polygon. And with the ſame Semidiameter D A you muſt deſcribe a whole Circle, of the which A B is the $\frac{1}{7}$ part thereof, which Diſtance will reach from B unto X, and from X unto Y, and ſo to Z, and your firſt Point at A, where you begun your Work.

For the other Baſtions, they may be eaſily tranſported from the firſt Baſtion. And note, That if your Fort exceed 8 Bulwarks, you muſt add 15 *deg.* to halt the Polygon Angle, ſo have you the Baſtion Angle; and then work as before. But in the Forts that exceed not 8 Bulwarks, where the Baſtion Angle will not be above 90 *deg.* you muſt take the $\frac{2}{3}$ part of the Angle of the Polygon.

The longeſt Line of Defence is from A unto Q, and ſhould not exceed 720 Foot (becauſe of being within Musket-ſhot) the Curtain R S about 420 Foot, and the Front A K 280 Foot: And for the Flank R K, and Gorge R O, their proportion commonly is as 6 to 7: but the Angle K O R forming the Flank is about 40 *gr.* by which the Proportion is neer as 5 to 6.

A Table



A Table for 8 Bastions.

	Polygons.	½ Angle of the Polygons	½ Angle of the Bastions
		Degrees.	Degrees.
4	Tetragon	45	30
5	Pentagon	54	36
6	Hexagon	60	40
7	Heptagon	64 3/7	42 6/7
8	Octagon	67 1/2	45

The ⅓ Bastion Angle is here found by taking the ⅔ of the ½ Polygon Angle: So the Bastion Angle will be an Angle of 90 *degr.* in the *Octagon.* And so more must the Bastion Angle be in any Polygon.

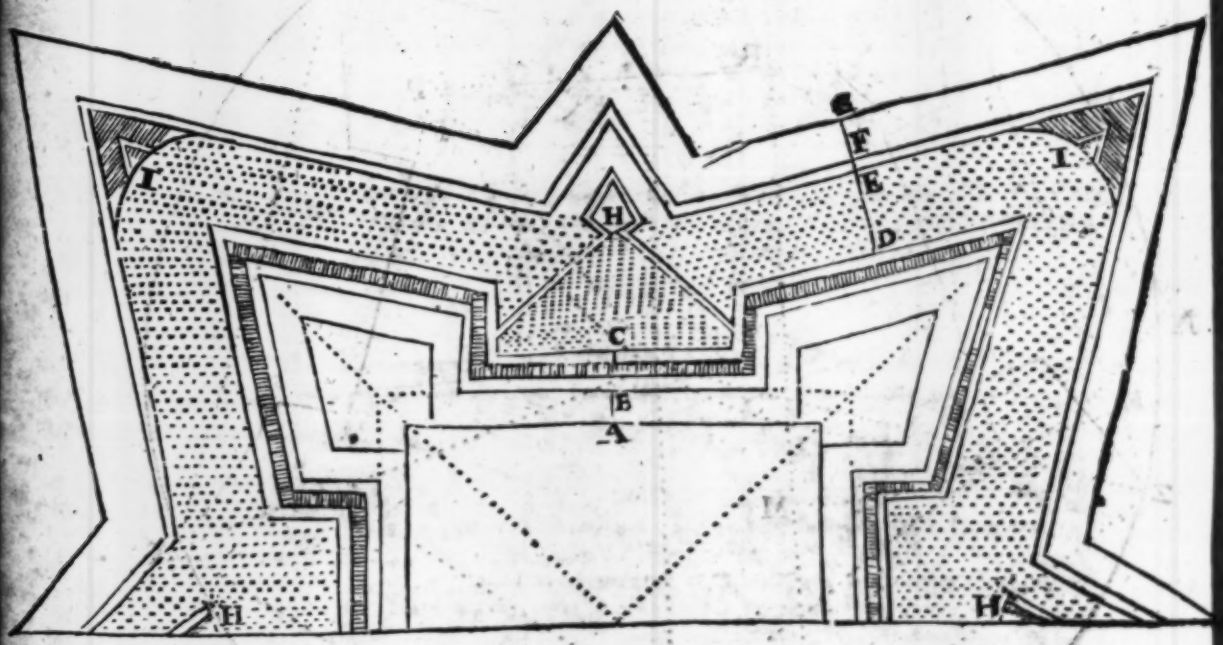
A Table for 12 Bastions.

	Polygons.	½ Angle of the Polygon.	½ Angle of the Bastion.
		Degrees.	Degrees.
4	Tetragon	45	30
5	Pentagon	54	34 1/2
6	Hexagon	60	37 1/2
7	Heptagon	64 3/7	39 9/14
8	Octagon	67 1/2	41 1/2
9	Enneagon	70	42 1/2
10	Decagon	72	43 1/2
11	Undecagon	73 7/11	44 7/22
12	Dodecagon	75	45

The ⅓ Bastion Angle is here found by adding 15 *d.* to ½ the Polygon Angle, and take the ⅓ thereof: So the Bastion Angle will be an Angle of 90 *deg.* in a *Dodecagon.*

Of

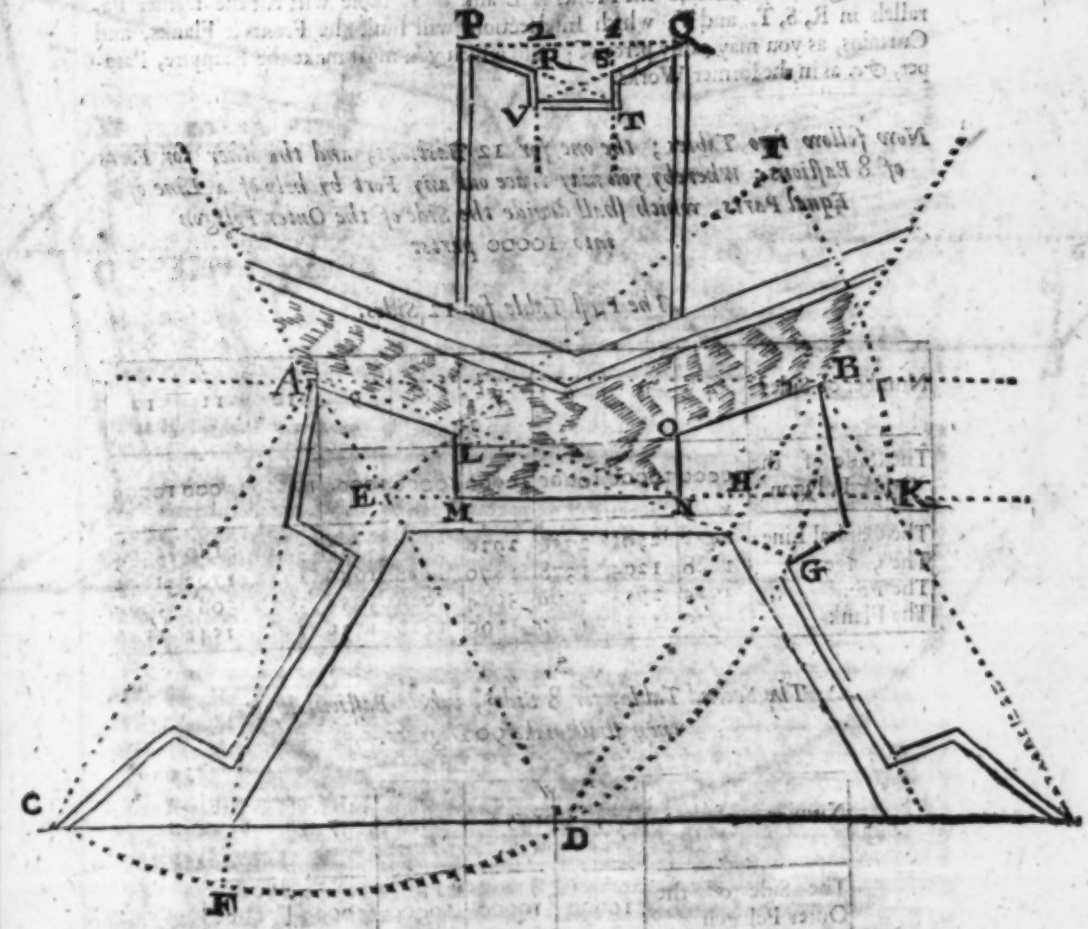
Of the Works that are in or about Forts of moſt Importance.



A B the Breadth or Walk on the Rampire	40	*Feet.*
B C the Breadth of the Parapet of the Rampire, with the Fauſſe-bray, and Parapet thereof, each 20 Foot; in all	60	
D E the Breadth of the Moat, Ditch, or Trench	120	
E F the Coridon, or Covert-way of the Counterſcarp	20	
F G the Argin or Parapet thereof, being	50 or 60	
H the Ravelines; I the Half-moons, with their Parapets	20	

There may be ſometimes an occaſion in Forts to raiſe Mounts, Cavaliers, Platforms, or Batteries, to command all the other Works, and to view the Country about; which may be raiſed upon the Baſtions, if you have room withal to make uſe of the Flanks: Otherwiſe let them be raiſed on the Curtains, a little within the Rampire, ſo that you may have room left for the Walk.

To Draw the Platform of a Fort, beginning with the Capital (or Head) Line; And alſo to draw the Horn-works.



LEt the Fort be an *Hexagon*, that is, of ſix Baſtions or Bulwarks. Firſt draw the Line A B, and upon A deſcribe an Arch of a Circle, as B D C, whereon lay down half the Polygon-Angle, which in the former Table you ſhall find to be 60 *deg.* as from B unto D, and thence to C; and draw A C and A D. Now the $\frac{1}{7}$ part of the half Polygon Angle is B G and C F; then draw the Obſcure Line A F and A G. Next you ſhall make choice of the Capital Line, of any ſufficient length, which let be A E; and from E draw a Line parallel to A B, as E H, continued; and upon the Point E, as a Center, deſcribe K I, making it an Angle of 40 *deg.* as K E I; ſo ſhall E I cut out the Front in L, as A L. So from L let fall the Perpendicular L M, which ſhall be the Flank; and M N the Curtain ſhall be as formerly the whole length of the Front, and a half more. For the reſt of the Work, you muſt proceed as formerly.

For

For the Horn-works.

YOu muſt continue the Flankers M L and N O unto P and Q; then take the longeſt Line of Defence A N, and lay it thereon from the ſhoulders at L and O, unto P and Q; drawing the Line P Q, dividing it into three equal parts; and from thoſe parts 1 and 2, draw parallels unto P L and Q O: alſo from thoſe Points P and Q draw parallels to the Fronts A L and B O, thoſe will cut the former Parallels in R, S, T, and V, which Interſections will limit the Fronts, Flanks, and Curtains, as you may eaſily perceive; unto which you muſt make the Rampire, Parapet, *&c.* as in the former Works.

Now follow two Tables; the one for 12 Baſtions, and the other for Forts of 8 Baſtions; whereby you may trace out any Fort by help of a Line of Equal Parts, which ſhall divide the Side of the Outer Polygon into 10000 parts.

The Firſt Table for 12 Sides.

Number of Sides	4	5	6	7	8	9	10	11	12
The Side of the Outer Polygon	10000	10000	10000	10000	10000	10000	10000	10000	10000
The Capital Line	2428	2592	2756	2926	3086	3136	3148	3180	3204
The Gorge	1088	1264	1378	1470	1538	1640	1722	1792	1842
The Front	2914	2952	2986	3014	3024	3054	3070	3082	3094
The Flank	970	1128	1246	1360	1516	1526	1536	1542	1546

The Second Table, for 8 Sides, whoſe Baſtion Angle then ſhall make 90 Degrees.

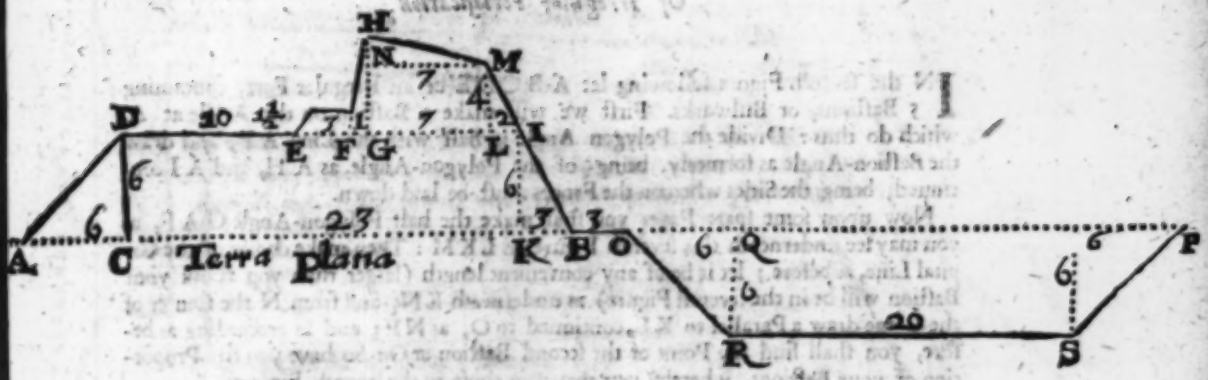
Number of Sides	4	5	6	7	8
The Side of the Outer Polygon	10000	10000	10000	10000	10000
The Capital Line	2396	2498	2602	2695	2778
The Gorge	1120	1427	1480	1599	1698
The Front	2914	2939	2959	2975	2987
The Flank	940	1113	1242	1342	1423

The Uſe of theſe Tables.

LEt it be required to draw the Proportional Dimenſion of a Regular Fort of 6 Sides: As for Example, in the fourth Figure, whoſe Side A B muſt be divided into 100 equal parts, and each part ſuppoſed to be ſubdivided into 10 parts: ſo have you 1000 parts, which ſhall ſuffice. Now proceeding according to former Directions, until you come to make choice of your Capital Line, you ſhall here find in the ſecond Table, which is beſt for the purpoſe, under the Figure 6, and right againſt the word *Capital* in the firſt Column, 2602, but 260 will ſerve: Take the

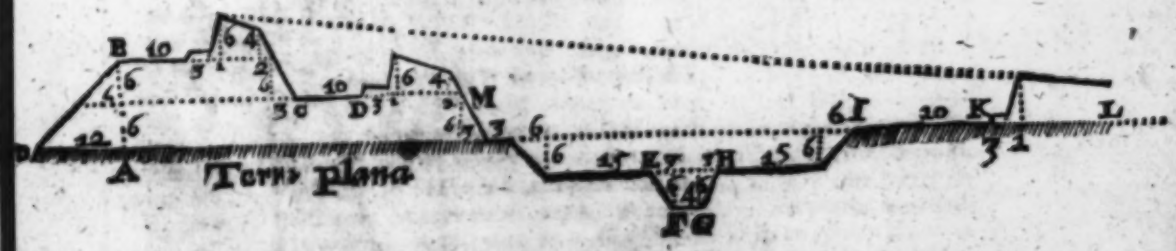
ſame

ſame from the Scale of Equal parts, and lay it from the Baſtion Point at A, and it falls in the Point E, which will be the Center of the Baſtion. From thence you may lay down the Gorge Line out of the Table, which is 148 unto M: So will the Front A L be 296, and the Flank M L. The Curtain, being once and a half the length of the Front, will be M N 444. Thus you may do for any of the reſt. Theſe Tables are uſeful for Irregular Forts; But firſt I will ſhew you the Height, Breadth, and Scarpings of the Rampire, Parapet, Ditch, &c. of theſe Sconces, as they are repreſented in the Profile, or Section, as followeth.



The Breadth of the Rampire may be 24, 30, or 40 Foot; but here A B is but	32
The Inward Scarp A C	6
The Height of the Rampire C D	6
The Breadth of the Walk of the Rampire D E	10
The Breadth of the Bank or Foot-pace of the Parapet E F	3
and the Height of the ſame Foot-pace	1½
The Inward Scarp of the Parapet F G	1
The Inward Height of the Parapet G H	6
The Breadth of the Parapet at the Foot F I	10
The outward Scarp of the Rampire B K	3
The Inward Scarp of the Parapet I L	2
The Outward Height of the Parapet L M	4
The Thickneſs of the Parapet at the top M N	7
The Brim of the Ditch B O	3
The Breadth of the Ditch at the top O P	32
The Scarp of the Ditch O Q	6
The Depth of the Ditch Q R	6
The Breadth of the Ditch at the Bottom R S	20

The Profile or Section of a Fort with a Fauſſe-Bray and Counterſcarp; alſo Subtrenched.



C D is the Fauſſe-bray, and D M his Parapet: E F G H is the Subtrench, and I K the Coridor, or Covert-way. Laſtly, K L is the Argin or Parapet of the

Counterſcarp. Note, That the Height of the Rampire A B ought to be raiſed 15 or 18 Foot above the *Terra Plana*, although here it is but 12 Foot, which is ſomewhat too low to command the Trench or Ditch: But if the Trench be made broader, then it will command the bottom thereof.

Of Irregular Fortification.

IN the ſeventh Figure following let A B C D E be an Irregular Fort, containing 5 Baſtions, or Bulwarks. Firſt we will make a Baſtion on the Angle at A, which do thus: Divide the Polygon Angle in half with the Line A F, and draw the Baſtion-Angle as formerly, being ⅓ of the Polygon-Angle, as A H, and A I continued, being the Sides whereon the Fronts muſt be laid down.

Now upon ſome ſpare Paper you ſhall make the half Polygon-Angle G A F, as you may ſee underneath this ſeventh Figure, as L K M: Then make choice of the Capital Line, as before; let it be of any convenient length (larger than you think your Baſtion will be in the ſeventh Figure) as underneath K N, and from N the Center of the Gorge draw a Parallel to K L, continued to O, as N P; and ſo proceeding as before, you ſhall find the Point of the ſecond Baſtion at O: So have you the Proportion of your Baſtions, whereby you may gain thoſe in the ſeventh Figure.

Now to reduce it from the Baſtion Point at A, you muſt take A B the ſhorteſt ſide, and lay it from O unto Q; and from Q draw a Line parallel to the Capital Line K N continued, as Q R. Laſtly, drawing a Line from N to O, it ſhall cut Q R in the Point S; ſo is Q S the length of the Capital Line ſought for, which muſt be laid down on the ſeventh Figure from A unto T; ſo is T the Center of the Gorge. Then for the Front take K V, and lay it on the Capital Line from K to W: ſo a Ruler being laid from W to O, it ſhall cut the Line Q R in the Point at X; ſo is Q X the length of the Front, to be laid down in the ſeventh Figure from A unto H and I. Thus ſhall you finiſh your Baſtion, when you have let fallen your Flanks perpendicular on the ends of your Curtains, as you ſee. The like Method you are to obſerve for the other Baſtions.

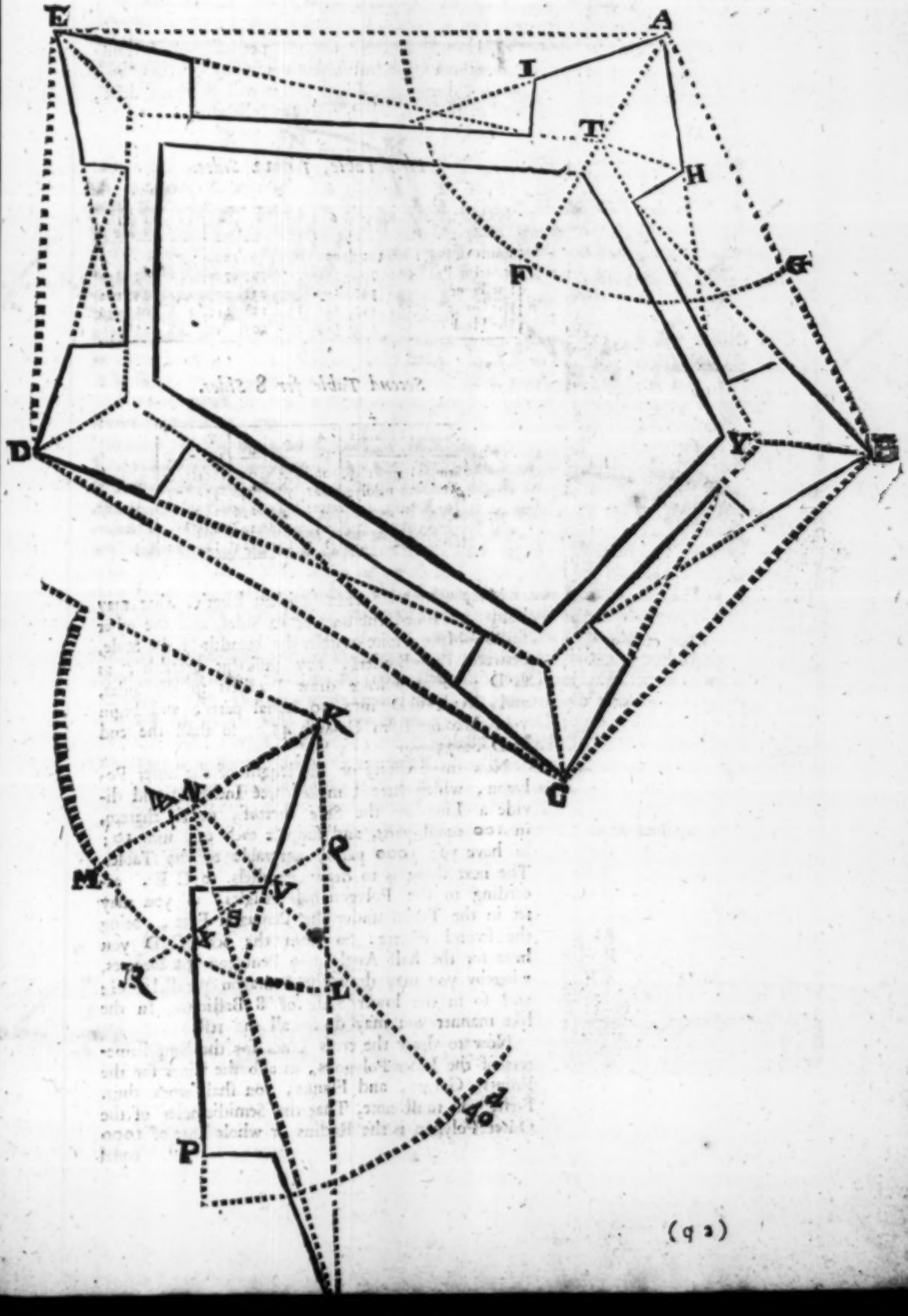
And when you have finiſhed your Fort, you muſt obſerve whether your Curtain Lines (that is, from the Centers of the Gorge) be parallel to the outward Sides A B, *&c.* which if they are not, you muſt correct them; and by your Judgment, by help of the Lines of Defence, you may as you ſee occaſion widen the Necks of the Gorges, and alſo the Baſtion Angles; but not above 90 Degrees: And ſo let the Flankers be as neer proportional as the Rules (or Ocular Demonſtration directeth) which commonly the Gorge Line to the Flank bears proportion as 7 to 6.

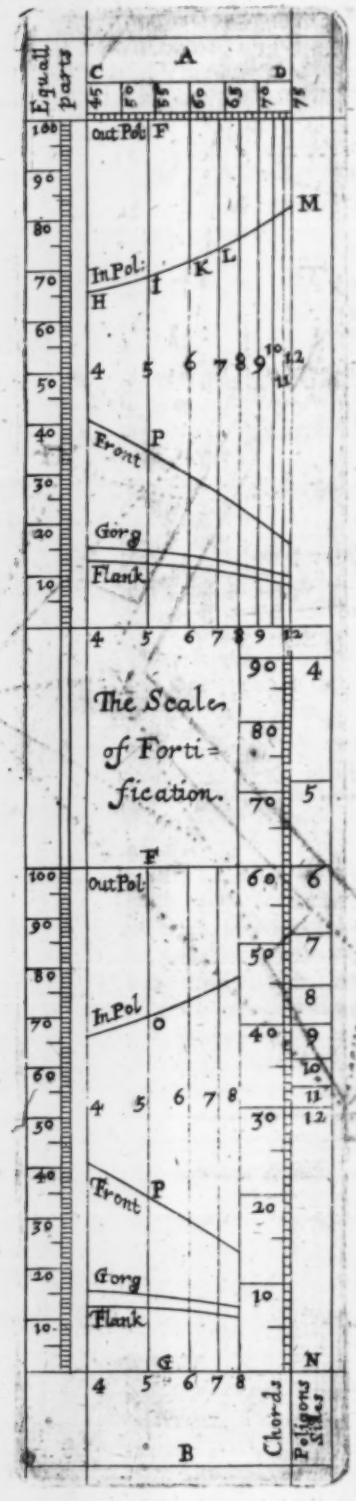
Much more could I write of Irregular Fortification: but my purpoſe at this time is but to make a ſmall Treatiſe, or an Epitome thereof.



The

The ſeventh Figure, of an Irregular Fort, containing 5 Baſtions; being the Platform of the Royal Fort ſometimes on St. Michael's Hill, *on the North weſt Side of the City of* Briſtol.





To make a Scale for Fortification by the Tables.

THis may be performed Geometrically by obſerving the former Inſtructions, whereby you may gain the length of every Line: but it will be ſooner done, and more eaſie, by theſe Tables following.

Firſt Table, for 12 Sides.

Numb. of Sides	4	5	6	7	8	9	10	11	12
Semi. Out. Pol.	1000	1000	1000	1000	1000	1000	1000	1000	1000
Semi. Inn. Pol.	661	700	731	756	777	795	810	823	834
The Front	412	347	299	261	231	209	192	174	160
The Gorge	158	151	141	132	123	115	108	101	96
The Flank	133	127	119	111	103	97	90	85	80

Second Table for 8 Sides.

Number of Sides	4	5	6	7	8
Semi. Outer Polyg.	1000	1000	1000	1000	1000
Semi. Inner Polyg.	661	706	740	766	787
The Front	412	346	296	259	229
The Gorge	158	156	148	138	130
The Flank	133	131	124	116	109

Make your Scale of a ſuffeient length, that may hold both Lines, the one for 12 Sides, and the other for 8. Make choice within the breadth of the Scale, between the Borders, any ſufficient breadth, as G D; from whence draw Parallels to the Sides, and divide C D into 90 Equal parts, and begin your Account from C with 45: ſo ſhall the end at D be 75 *degr.*

Now make choice of the length of the outer Polygon, which here I make three Inches; and divide a Line by the Side thereof, equal thereto, in 100 equal parts, and ſuppoſe each part into 10; ſo have you 1000 parts, agreeable to the Tables. The next thing is to draw Parallels to C E, according to the Polygon half Angles, as you may ſee in the Tables under the Pentagon Fort, being the ſecond Figure: So from the Scale C D you have for the half Angle of a Pentagon 54 Degrees, whereby you may draw the Pentagon parallel F G; and ſo in the lower Scale of 8 Baſtions. In the like manner you may do for all the reſt.

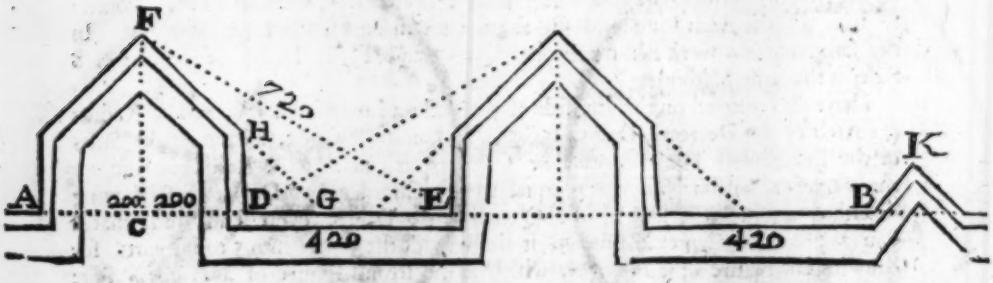
Now to draw the croſs Lines for the Semidiameters of the Inner Polygons, as alſo the Lines for the Fronts, Gorges, and Flanks, you ſhall work thus. Firſt, you muſt note, That the Semidiameter of the Outer Polygon is the Radius or whole Line of 1000 equal

equal parts, and that is drawn at Right Angles, or a croſs at F: But for the Semidiameter of the Inner Polygon, look in the Table of 12 Sides in the ſecond Column under 4, you have 661. Take the ſame Number off your Scale of Equal Parts, and lay it from E to H: Then in the third Column under 5 you have 700 parts; lay the ſame down from G to I, and make there a prick or point: Do the like for the *Hexagon* and *Heptagon*, as at I and K; proceeding along with all the reſt, unto the *Dodecagon*. And laſtly, draw a Line through all thoſe Points: So have you the Arch Line H M for the Semidiameters of the Inner Polygon. In the ſame manner work for the Front, Gorge, and Flank Lines. The Scale of 8 Sides is the ſame Method.

I have alſo inſerted on the left ſide of the Scale a Line of Chords, whoſe Radius (or Arch of 60 Degrees) is three Inches; and on the left ſide, a Line for the Sides of the Polygons. The *Hexagon*, or ſix Sides, is equal to the Radius: And for the *Tetragon*, or four Sides, it is equal to the Chord of 90 Degrees. So having deſcribed a whole Circle with the Chord of 60 Degrees, you ſhall find, that if you take from the Center N unto 5, it ſhall divide the Circle into 5 equal parts, for drawing the Figure of a *Pentagon*, which in the ſecond Figure of a *Pentagon* Fort will reach from A to B, and ſo to X, Y, Z, and A. Now D A in the ſame ſecond Figure you ſhall find to be the Semidiameter of the Outer Polygon, which in the Scale is G F; and taking G I off the Scale for 12 Baſtions, or G O on the Scale of 8 Baſtions, it will give the Semidiameter of the Inner Polygon, as D E in the ſame Figure. So likewiſe G P on the Scale will be equal to the Front A K in the *Pentagon* Fort. The like you may underſtand for laying down the Gorge and the Flank. And for the Curtain, as before, you muſt make R S 1 $\frac{1}{2}$ the length of the Front A K.

This Scale will alſo be of good Uſe in Irregular Fortification. As for Inſtance. In the Irregular Fort, the ſeventh Figure, you ſhall find the half Baſtion Angle G A F to be 58 Degrees, which falls on the Scale between the *Pentagon* and *Hexagon*, from whence you may draw a Baſtion on ſome ſpare place, and from thence proportionate the ſame unto the outer ſide of the ſeventh Figure A B. The reſt I leave to your own practice.

How to Fortifie a long Curtain with Bulwarks, or a ſtrait Town Wall.

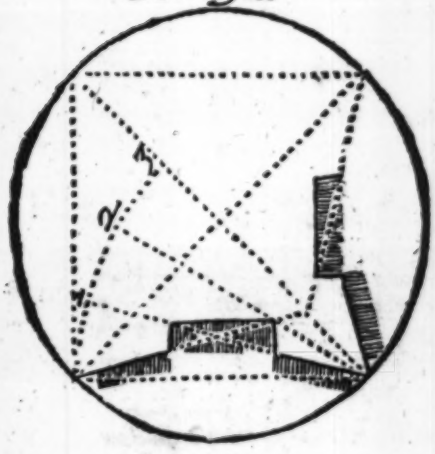


LEt the Curtain be A B. Firſt take 200 Foot from the Scale of Fortification, accounting 10 for 100; and lay the ſame from A unto C, and from C unto D: So ſhall A D be the breadth of the Neck of the Gorge: and upon the Point C erect a Perpendicular, as C F. Then take 420 Foot off your Scale, and lay the ſame from D to E, which ſhall be the length of the Curtain. Next you muſt take 720 Foot, and lay the ſame from E, to cut off the Capital Line at F; ſo ſhall E F be the longeſt Line of Defence, and C F the Capital Line; which Line C F muſt be laid down from C unto G: and draw G F for the ſhorteſt Line of Defence. Laſtly, upon D erect a Perpendicular, which will cut the ſame Line in H; ſo have you D H for the Flank, and H F the Front. Thus have you finiſhed half the Baſtion, from whence you may tranſport all the reſt of the Baſtions, were they ever ſo many.

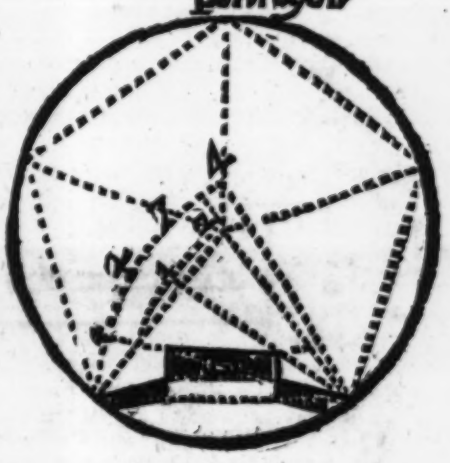
Note, That theſe Baſtions muſt not exceed 720 Foot, that ſo it may not be without Musket-ſhot. But if you will defend the Front with Cannon, you may make the Line of Defence almoſt twice ſo much. The like for the Curtain, which may be 800 Foot; and in the middle of the Curtain you may make a Spur, or Point of a Baſtion, as at K, which will be neceſſary for Musket-ſhot, beſide the Cannon; which in the Line drawn about the City of *Briſtol* I have ſeen many of them.

These five following Pieces are taken out of Malthus; *The Proportions you may find by the Scale, and the Rules before shewed.*

Tetragon



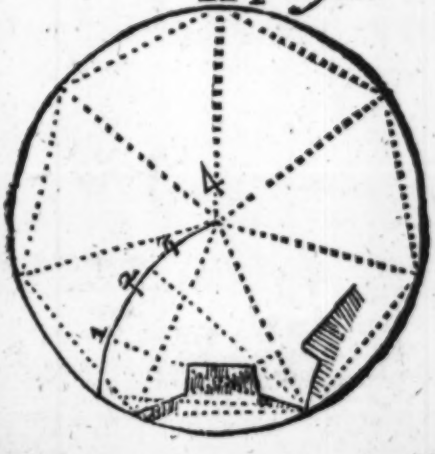
Pentagon



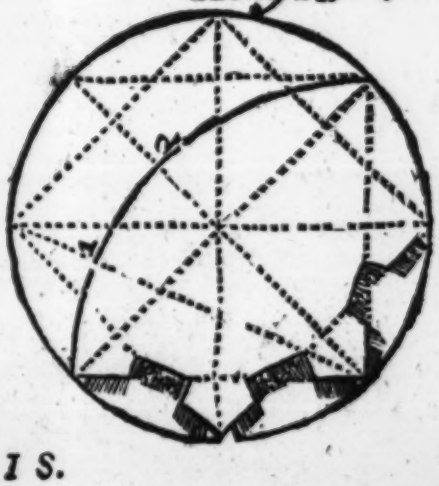
Hexagon



Heptagon



Octagon



FINIS.